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Personnel Selection of Graduate Engineers

The Differentiation of Apprentice Engineers for Training as Salesmen, Designers, and Executives of Production

BY

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FOREWORD

This volume is a contribution to psycho-technology. Mr. Moore has made, in the following experimental and statistical study, the first approach toward a scientific solution of the problem of placement of engineering graduates in a great American industrial organization.

It is a bold and novel undertaking, characteristic of a young century, to essay the application of the principles and technique of scientific method to the solution of human problems in industry. Yet it needs no rare wit to see that these very problems of human adjustment must hold during the twentieth century the focus of study and invention which during the nineteenth century were chiefly concentrated on the problem of perfecting the mechanics of manufacture. Human engineering is destined to a development comparable to that experienced by mechanical, chemical, and electrical engineering, when they first began to draw largely on the lustily growing sciences of chemistry and physics. Thanks to the foundations laid by these sciences, modern industry has a highly developed technology of materials and processes. It asks now for a technology of human nature.

This study in principles and practices of personnel selection is not a popular treatise. But its appeal will be felt by at least three types of readers: the thoughtful leader of industry who ponders the trend of scientific experimentation on human problems; the young engineering graduate who is debating in his own mind whether to become a designer, a manager, or a salesman; and the psychologist who is watching, with some apprehension, the movement to put into practical use the tools he has forged.

W. V. Bingham,
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Carnegie Institute of Technology.

PREFACE

This report is a description of a specific study on a practical problem. Certain principles and practices are proposed as conclusions from this study. The practical problem was to determine methods and means for selecting young engineers just being graduated from college and placing them in the type of work which they could do best in a large electric manufacturing company. The outstanding feature of the problem was to select the men best qualified to develop into sales engineers; that is, engineers who meet the public and sell electrical machinery. The study was made primarily to solve the practical problem; and then the principles underlying the solution were formulated in order that they might be applied to further problems. In other words, the research was made for service, in the belief that it was possible to give service and at the same time make a contribution to science.

As a practical investigation the work is already giving service. The results already obtained on one hundred seven engineers employed by the firm during the first year that the new methods recommended here have been used, are very similar to the results obtained on the group studied in this research. Assuming that the executives classified the men correctly at the end of a year, we can say that the results of the test alone would have classified seventy per cent of the men correctly on the day that they were employed. Beginning with June, 1921, the company will use the test and other methods recommended here as definite aids in classifying and placing graduate engineers whom they employ.

Progress in psychology, as in any other science, has been made by specialization and intensive study on a specific problem. Quite often in science both the motive and the opportunity has been a practical problem in industry. The growing realization that the human factor is a most important one in industry has given both motive and opportunities for research on specific problems in psy-

chology, the science of human behavior. The business world is appealing to psychology as a science to solve specific problems. Some psychologists have already brought forth and exploited the facts, the technique, and the point of view of their science, in the hope that the science might be advanced as a science as well as be made to serve man in utilitarian ways. For accomplishing both purposes, the first and most important principle is that one definitely narrow and specific problem after another must be attacked and solved to contribute its portion to the cumulative content of the science.

This report of a study on such a specific problem has been written in a comparatively brief and concise form. It is intended for practical use; but also it is intended to be read in its entirety only by those who understand the language of psychology and statistical methods. The original tables of data are not presented; and much of the explanation is omitted which might be included in an exhaustive treatise. The tables and all other details of the study are on file with the Division of Applied Psychology, Carnegie Institute of Technology, and are available for all who may wish to examine them. However, it is believed that the report is sufficiently complete to enable those who have an intelligent interest in such a problem to grasp what the study has to give.

ACKNOWLEDGMENTS

Many people have helped make this research possible. First, it was the coöperation of the Westinghouse Electric and Manufacturing Company that made it possible to carry on the research in a large industry with a definite practical problem before me that would yield fundamental principles. This large industrial firm made it possible to have the study include a sufficiently large number of selected subjects to make the results more reliable than they would have been otherwise. In this report I wish to make special acknowledgment of the help given me by Mr. C. S. Coler, Manager of the Educational Department, and Mr. E. B. Roberts, Mr. W. E. Freeman, Mr. F. G. Kottman, and others of the Educational Department; also Mr. B. G. Lamme, Chief Engineer, and Mr. H. E. Jordan and Mr. H. B. Bassett of the Engineering Department; and Mr. S. L. Nicholson and others of the Sales Department.

I am indebted to Professor E. L. Thorndike of Columbia University for the "True-False" statements which I took from his test and incorporated in Part II of the test which I devised. Also I received many suggestions from Professor L. L. Thurstone's tests which he prepared for the Society for the Promotion of Engineering Education. I wish to acknowledge the valuable technical aid given to me by Professor W. R. Work and Mr. G. M. Porter of the Department of Electrical Engineering, Carnegie Institute of Technology.

Finally, but not least, I wish to thank Dean W. V. Bingham and Professor L. L. Thurstone of the Division of Applied Psychology, and Director C. S. Yoakum, Associate Director W. D. Scott, and the Research Fellows of the Bureau of Personnel Research, Carnegie Institute of Technology, for their suggestions and the many ways in which they have helped make this work have whatever value there is in it.

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PART I. THE PROBLEM

I. The Practical Problem

The Westinghouse Electric and Manufacturing Company each year employs about three hundred engineers who have just been graduated from technical schools and colleges. All these men have had practically the same training; but they must be differentiated and placed in different lines of engineering according to their special interests and aptitudes. The aim is not to discover which engineers are best for any particular kind of work; for a few very capable men might be best in all lines; but the aim is to discover in what line of work each engineer will function most efficiently and satisfactorily. That is, the desired end is to have each member of the organization so placed that he is able to render his greatest service to the Company by having the greatest opportunity to develop his capacities and promote himself in the line of work which he most enjoys. The practical problem is to determine methods and means for selecting and placing young engineers in the type of work which they can do best.

For selecting, differentiating, and properly assigning graduate engineers to the various phases of engineering and salesmanship, five methods or means and combinations of them are possible, namely:

1. Grades made in the technical schools;
2. The grades, try-outs, and observations secured during the year of preliminary training in the firm's educational department;

3. Rating scales;
4. Interests and desires of graduate engineers;
5. Psychological tests.

The second and fourth, interests, and observation during training are the ones emphasized at present; and in fact they are the best methods, at least until new methods are evaluated. However, these methods are not entirely satisfactory nor ideal; for the interests or choices of the men are uncertain guides and are not always identical with the needs of the company; and often the graduate engineers cannot decide themselves what work they would prefer. The process of trying out under observation during training can be done only after a certain amount of selection and differentiation has been made, and the Company has more or less committed itself in regard to its future engineers and salesmen. The training could be made more definite and intensive if it were known from the beginning, to just what line of work the graduate engineers should be assigned. Moreover, a more or less definite quota is needed for each line of work, and those men should be selected from the technical schools who would most exactly be the number required for each line of work. Finally, but not least important, the method of trying out under observation fails to reveal for what the graduate engineer is best fitted; and at best, there is often an uncertainty or question as to what work should be assigned. To meet the conditions just described, the first and second methods are analyzed, but attention is concentrated upon the development and application of the third, fourth, and fifth methods named above, that is, rating scales, survey of actual interests, and psychological tests.

II. The Psychological Problem Involved

Broadly speaking the psychological problem is one of individual differences relative to capacity for doing specific kinds of work. The previous policy was to classify and assign or place the engineers according to their interests, the practice being limited somewhat by the openings or needs in the Company and by the general impressions which the executives had of the young engineers. The big question raised was whether the men were

being placed where they could function most efficiently. Were their interests a reliable criterion of their ability? This leads to the fundamental psychological questions: (1) Is marked ability in a particular line of work only general ability or intelligence directed by interest? (2) Are there different kinds of intelligence? (3) Is there one thing called general intelligence, and additional abilities which are special and which vary independently? (4) Is interest an indication of a special ability in a particular line or work? (5) Are there only special abilities, not necessarily correlating with a general average of these, which is called general intelligence? (6) Does success in a particular occupation depend upon purely intellectual ability, or are the more or less vaguely defined personal traits the more important for success? (7) When it is learned which of these factors are important, how can they be measured so as to make a prediction or a statement of the probability of success in a particular job? Summarizing these questions, we state the psychological problem as follows: To determine what mental abilities and traits are of practicable use as criteria for differentiating graduate engineers and predicting their success in six different but closely related kinds of work. This problem includes the evaluation of old methods and means and the devising of new methods and means for determining and measuring these mental abilities and traits. It is not to be expected that we should answer all the questions stated above, which have already taken years of work by the best psychologists, and will require much more work; but these questions should be recognized as pertinent in the assumptions and conclusions of this study.

This being a specific study with a definite problem in applied psychology, it does not include in its purpose and scope any historical or theoretical treatment of many general psychological problems which may be touched upon. Very few studies that have been published deal directly with this kind of problem. However, at the end of this report is appended a bibliography or list of studies which bear more or less specifically upon a problem of this nature.

PART II. THE LINES OF INVESTIGATION AND THE RESULTS

III. Occupational Descriptions and Analyses

The first important step in all personnel selection and placement is to secure adequate descriptions and analyses of the jobs to be filled. Then from these there must be prepared specifications for the persons who will most nearly meet these requirements. The specification is an interpretation of the work done on the job, in terms of capacities, skill, knowledge, and traits required to do the work. In practice the degree of specificity to which these descriptions are carried varies considerably from firm to firm and with different lines of work. In general discussions it is quite common to refer to the various *vocations,* which differentiate only the general lines of work typified by the various professions and trades. Often in employment and placement work, differentiations are made only into *occupations,* which are understood to be the specialties in the trades, such as punch press hand, lathe hand, die sinker, armature winder, etc. Strictly speaking, the *job* description is reserved for a description of a particular operation on a particular piece of material or apparatus by means of a particular tool or machine. In the Westinghouse Electric and Manufacturing Company these distinctions are made in the use of these terms by the Occupations and Rate Committee and by those in the Employment Department.

In the Westinghouse Electric and Manufacturing Company the employment and placement of the engineers is done by the Educational Department. Each spring this department selects between two and three hundred engineers from the senior classes of the technical colleges; and after giving them a year of graduate training in the Educational Department at the central plant in East Pittsburgh, it places these men in the various lines of work in the organization. Before it was possible to choose any certain engineers as better fitted for certain lines of work, it was necessary to know what was expected of these engineers in each line of work. As there were not on record any descriptions or specifications of the work done by the engineers in the various

departments, this information had to be gotten first. The descriptions of the lines of work were obtained through the Educational Department.

After conferences with some of the executives who could tell most about the various lines of work, a description and outline of the nature of the occupational description desired was given to the Educational Department. Under the supervision of the Educational Department the occupational descriptions were prepared by the heads of the various sections in each of the departments. These were elaborated further by means of conferences with various executives in which questions were asked to clear up obscure details. Finally, in this manner, a conception of each line of work was obtained, which was detailed enough for working intelligently on the problem of selection and placement.

It would be out of place here to give an exhaustive description of each job or line of work in each section of each department. Moreover, such detailed descriptions are not necessary for understanding the problem that is before us. The complete occupational descriptions are on file with the Division of Applied Psychology, Carnegie Institute of Technology, and are available for those who wish to examine them. It is sufficient here to have a description of the main classes of engineering work. In actual work upon the problem, only four classes of engineers are considered, namely: (1) research workers and design engineers; (2) general or all other engineers in the engineering department; (3) operating, service, and works management engineers; (4) sales engineers. This was found practicable because nearly all the engineers were graduates of technical colleges and had received essentially the same technical training. Moreover, this process of being admitted to the technical colleges and of being graduated from them, had been highly selective so that any differentiation among the men was possible only by comparatively fine discrimination. In fact, the one real differentiation that was consistently kept in mind in all this study was that between the engineers going into the sales department and all other engineers. This might be qualified or rather more definitely stated by explaining that the design engineers were also differentiated from

the other engineers, and being considered as representing the purest type of engineer, they were also considered as at the opposite extreme from the sales engineer when the differences were looked at as quantitative or linear in nature. The descriptions of these lines of work are given with particular attention to those lines considered to be most clearly differentiated. Combined with these descriptions are given the specifications for the kind of men considered best fitted for each particular line of work.

1. *Functional Classification of Engineers*

Within the organization, the engineers are classified according to the department and according to the class of product worked upon. Since the specifications for the kind of engineer needed depends upon the kind of work done, we must classify the engineeers according to the qualifications required to do the particular kinds of work: (a) In all the specialized engineering departments which are responsible for the engineering work on different particular lines of electrical apparatus and machinery, thus excepting the General Engineering Department and the Testing Department, there must be design engineering. This calls for engineering of the purest and highest type. With this type of engineering is also classed the research worker in the Research Department. (b) All the other engineers of the engineering departments are to be considered as doing a second type of work. This work is engineering; but it is not to be considered as calling for as great mathematical and technical ability and as much originality in that line as is needed by the design engineer. (c) The third class includes the engineers in Factory Management, the Service Department, and Operating. The work of these engineers brings them, to a larger extent, in contact with other people outside the organization and also with those inside the organization. Their work requires more executive ability than the work done by the other groups of engineers. (d) The fourth class is that composed of Sales Engineers. These men are primarily engineers as well as salesmen; for to get and keep the good-will and confidence of the customers, they

must act as consulting engineers and give reliable technical advice to the customer or prospective customer. However, the successful engineer doing the work in the sales department must have a commercial sense and an ability to meet and successfully negotiate with other people, that differentiates him from the other engineers.

IV. Criteria of Success of Engineers

Closely allied and of equal importance with a definite knowledge of the jobs to be filled, are criteria of success of men in those jobs. Methods of selection and placement cannot be developed or improved upon unless it is possible to know when better results are obtained. The best criteria are objective measures, such as records of production; but it is seldom possible to obtain facts on such objective measures that are comparable. The work of sales engineers and of design engineers is such that it cannot be measured by the product finished. Although records of sales may be kept, many other factors enter into the value of a sales engineer to the company. The professional consulting service which the engineer gives to the customer, and the good-will secured in return, cannot be measured in that way. Also, a design engineer may spend all his time for a year or more on one machine or piece of apparatus; but if he gives the piece of apparatus an original design or makes it in the nature of an invention, his work is scarcely measurable. However, it is necessary to make use of the best criteria available.

The year spent in the Educational Department can be considered as one phase of the engineer's work. Therefore, grades and ratings on their success there are some criteria. Furthermore, the executives and instructors of that department come to know intimately all the student engineers during the year of training. To give some definite data against which tests and other ratings might be checked, the Educational Department was asked to rank the student engineers in the order of their general intelligence. General intelligence was defined for them as "the ability to analyze a problem, grasp the point, and deal with a new situation." Two men who both supervise the work of the engineers

and instruct them, worked together as a committee to rate the student engineers. They first classified the men into five groups according to their general intelligence, as defined. Then they ranked the men in each group in the order of their estimated intelligence. By combining the groups, with the highest rated group first, a ranking of all the engineers was secured.

Further checks on the reliability of ratings, test scores, and these grades were possible by intercorrelations. Although none of these were absolute measures of success, it was reasonable to assume that high intercorrelations between different kinds of measures, such as between grades and tests, or between estimates and grades would show that there was a certain consistency in the measures that correlated highly with other measures, and that there was no cause to believe that they were unreliable.

V. Evaluation of Technical School Grades

The representatives of the Company, in selecting engineers graduating from the technical schools, did not consider primarily the grades received by the engineers in their college courses. They interviewed the seniors for twenty or thirty minutes, and then later inquired about the man's grades in general. However, the grades were not considered as an absolute index of a man. Leadership and participation in extra-academic activities were considered as important. It is not always easy to obtain the grades in such a way that extensive and consistent use can be made of them. I thought that probably they would show something of the technical training and ability of the men, but that many qualities making for success in engineering and salesmanship were probably not to be inferred from such grades. However, a scientific investigation of this sort would not ignore them. Moreover, a study of these grades might give some light on the significance of grades given in the Company's training courses. Accordingly, I made a study of the grades which graduate engineers received in the technical schools. Many difficulties were encountered in attempting to deal with technical school grades statistically and to derive reliable conclusions.

Transmutation and Tabulation of Technical School Grades.—A letter explaining the nature of this study and the purpose in

requesting the grades was sent to over sixty different technical schools to secure the grades of 116 students. Transcripts of grades for 94 students were received. No two schools used the same form on which to record the grades; and there were at least seven distinctly different systems of grading with several variations of each system. The grades of men from different schools had to be made comparable. There were not enough men from any one school to make it possible to transmute their grades into standard deviations, so another method was adopted. The range of possible grades between the just passing grade and the highest possible grade, was learned either from the college catalogue or from the key on the transcript of grades. The median point on that scale was estimated and called the average grade. All such average grades were given a marking or value of 2. Grades above average were given a value of 3; and grades below average were given a value of 1. Grades below passing were given a value of 0; and exceptionally high grades in a subject, shown to be reliable by more than one highest marking on that subject, were given a value of 4. The method of transmutation of the grades can be shown by the following table which gives some comparable values.

TABLE I.

Transmutation of Technical School Grades into Common Values.

Common Values into which Grades are Transmuted.	0	1	2	3	4
System using per cents..	-69	70-79	80-89	90-97	98-100
System using letters.....	E	D	C	B	A
System using passing marks	F	P—	P	P+	All P+
System using descriptive terms	Fail	Poor	Good	Superior	Excellent
System using merits	Fail	Pass with low mark	Pass	Merit	Honor
System using points....	0-.9	1.0-1.9	2.0-2.9	3.0-3.7	3.8-4.0
System using class rank..	10% of class	20% of class	40% of class	20% of class	10% of class

In transmuting grades from institutions with high standards and strict grading systems, the evaluations were made higher than with institutions known to be below the average standing in the requirements it made of its students. Altogether, the transmutation was coarse as a statistical method; but it was the best that could be done with the data available; and it is considered sufficiently reliable to give significant indications.

All the subjects studied by the engineers were classified under five headings or general subjects, namely,—Languages, including English and foreign languages; Mathematics and Science, including mechanics, physics, chemistry, and all special phases of these exact and theoretical sciences; Shop; Engineering, including all kinds of engineering, but chiefly electrical and some mechanical; and all Academic subjects, which is, in the case of engineers, only history and economics.

Comparison of Technical School Grades with Other Criteria.—The first question to raise about the grades is in regard to their relation to success in industry or practical work. These engineers had not yet been in full-time work, but their year of work in the Educational Department and in the shop under the direction of that department, could be considered as one form of practical work in which success is to be determined. The estimates made by the committee of the Educational Department, explained under the title, "Criteria of Success," might be considered as one rating of success in the Educational Department. Grades given in the Educational Department classes, and grades given by the foremen on the shop work, can be considered as another check. Ratings on various qualities, explained in a section later, could be considered as the success of the men in impressing the foremen with their ability, and might be related to school grades. Also, the correlation between technical school grades and the ratings of the men made by the representatives of the Educational Department at the time of the employment interview, might be some measure of the extent to which the two measure the same qualities. Finally, a positive correlation between mental alertness or general intelligence test and college

grades would be at least some evidence that school grades were some indication of what is measured by tests as general intelligence or mental ability. The correlations between technical school grades and the various other measures or criteria are as shown in Table II.

TABLE II.

Correlations of Technical School Grades with Other Measures.

	No. of cases	Correlation (r)
Technical school grades with estimated intelligence, committee's rating	88	.0
Technical school grades with educational department class grades	60	.0
Technical school grades with foremen's shop grades	62	.0
Technical school grades with foremen's ratings on traits	85	.0
Technical school grades with ratings at interview for employment	21	+.22
Technical school grades with Bureau Test VI	56	+.37
Grades in languages with foremen's ratings on traits	59	.0
Grades in mathematics with foremen's ratings on traits	72	.0
Grades in shop with foremen's ratings on traits	31	.0
Grades in engineering with foremen's ratings on traits	66	.0
Grades in academic subjects with foremen's ratings on traits	44	.0
Grades in languages with Bureau Test VI	43	.0
Grades in mathematics with Bureau Test VI	54	+.34
Grades in shop with Bureau Test VI	24	+.67
Grades in engineering with Bureau Test VI	53	+.26
Grades in academic subjects with Bureau Test VI	35	.0

The correlation coefficients between technical school grades and other criteria, particularly the Company's Educational Department class grades, shop grades, and shop ratings, might be taken to indicate that the technical school grades are unreliable. However, I do not believe that this conclusion is justified. Rather, I believe that the shop and class grades, and the ratings are unreliable, or are largely the cause for the lack of correlation. The cause for this belief will be shown later in this report.

The composite of technical school grades shows a significant correlation with intelligence test scores. Doubtless the correlations would be higher if the grades were not from so many different schools with different standards. I believe that in any particular school, an average or composite of the grades received by each student would rank the students in general ability as well as any measure; but the standards of work and the methods of

grading are so incomparable in different schools that they can not be used by the employer to compare men from different schools. A standardized psychological test would show the same thing in much more reliable and usable form. That is, a general intelligence test given to a group of engineers selected from sixty different technical schools would give a more reliable ranking of the men according to their ability than a comparison of grades from these different schools; and the ranking could be obtained much easier by a test than by an attempt to transmute various systems of grades into a common scale.

The intercorrelations of the grades in the various subjects is shown in Table III. As might be expected, the correlation between closely related subjects, such as Mathematics and Engineering, ($r = +.57$) is greater than between what are usually considered less closely related subjects, such as Academic Subjects and Shop ($r = +.30$). There might be some *a priori* question about the correlations between Shop and Mathematics or between Shop and Engineering, but the correlations are shown to be comparatively high, being ($r = +.61$) ($r = +.42$) respectively. Shop grades correlate higher with Bureau Test VI scores than any other technical school subjects do; but the number of cases is so small that the large probable error makes the correlation coefficient highly unreliable. However, it will be seen later that the design engineers, who are picked men and are supposed to be the most capable men in pure mathematics and engineering, have the highest grades in Shop, and are differentiated more widely from the other engineers by the average of their grades in Shop. It seems that the grades that a man receives in his shop work in the technical schools is significant of his special engineering aptitude, and even of his general mental capacity.

For differentiating the engineers for the different lines of work which they are to do, I thought that grades in different subjects might be significant. The average grade in each main subject for each class of engineers was computed, and curves plotted to show the relation of one group of engineers to the others. (See Diagram 1.) The design engineers are above the

TABLE III.

Intercorrelations of Technical School Subjects.

Subjects	Number of cases	(r) Correlation
Languages with mathematics	77	+.38
Languages with shop	35	+.37
Languages with engineering	69	+.55
Languages with academic subjects	53	+.30
Mathematics with shop	43	+.61
Mathematics with engineering	85	+.57
Mathematics with academic subjects	57	+.42
Shop with engineering	63	+.42
Shop with academic subjects	21	+.30
Engineering with academic subjects	54	+.35

other engineers in every subject, indicating that they were superior students in the technical schools. The curves of the general engineers and of the operating, service, and works management engineers run comparatively close together, the average of one group in a subject rising or falling with the average of the other group of engineers. The average of the sales engineers varies inversely with the averages of the general and the operating, works, and service engineers. The significant feature of the averages, however, is that the design engineers are very much higher in all subjects, except the academic subjects, composed chiefly of economics, while in this subject the sales engineers have almost as high an average, although the general or all-around ability of the design engineers is evidently higher. The man who has been selected for other reasons as promising of becoming a good sales engineer, is the one who had special ability in the social sciences.

VI. Evaluation of Grades and Ratings Given During Training in the Educational Department of the Industrial Firm

As soon as the engineers, usually just graduated from the technical school, enter the employ of the Company, they begin the year of training in the Educational Department. Practically all the engineers spend the first two months taking the same courses and doing the same work. In addition to class work, they work about a month in one department of the shop and then pass on to another kind of work so as to become familiar

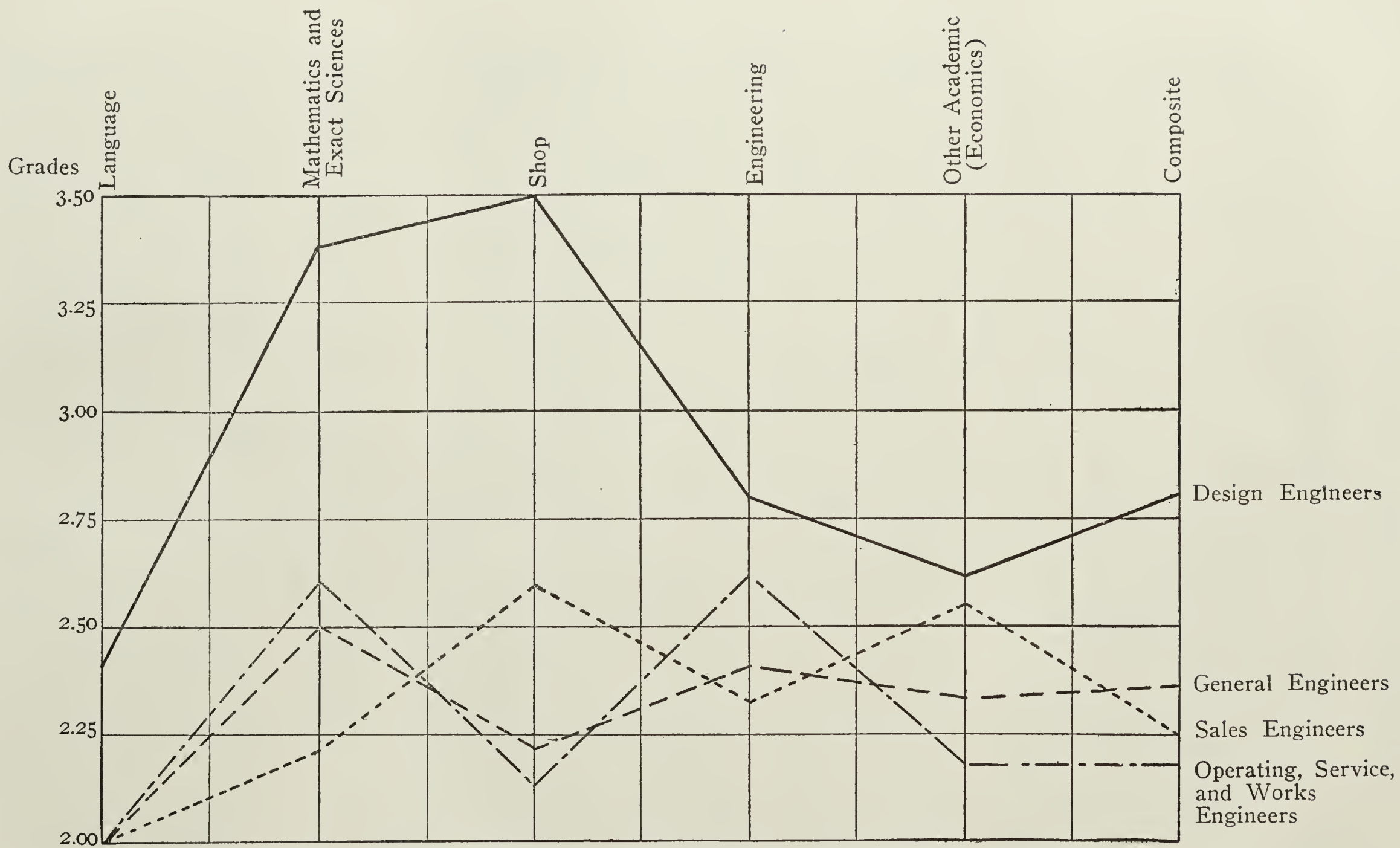

Diagram 1. Averages of Technical School Grades for Each Group of Engineers.

with as many phases of the manufacturing process as possible. To make the absorption of the men into the shop possible and efficient, the men have to be divided into many groups and sent into many different sections, but the work for all is very similar at first. At the end of two months, however, there is begun the work of segregating the men into groups according to the line of work that they will do permanently. That is, the sales engineers and the design engineers, works management engineers, general engineers, etc., are picked out. This process of transferring the men from one department to another and of determining to what line of work each will be eventually assigned, continues until the end of the sixth month. Beginning with the sixth month a Sales School and a Design School are started; and the engineers begin specialized training for their future work.

From the time that the engineers enter the Educational Department, extensive records of their work are kept. Most of the men are first assigned to industrial motor winding and are graded on that work, both in the classes and in the actual work in the shop. In this work, the correlation between the shop grades and the class grades was $r = +.19$, for 76 cases. The grades for any one group of engineers plotted separately showed no different correlations. This low correlation shows the disagreement of the impressions received by different people, and the unreliability of opinions concerning traits in people, particularly when the judgment must be made only after a short period of observation of the subject's work. The curves in Diagram 2, show that the design engineers receive the highest grades in the shops. This agrees with the fact that they received the highest grades in Shop in the technical school grades.

In addition to the grades in the different subjects or kinds of work, there come from the foremen over each department, ratings on various traits of the engineers working temporarily under these foremen. These ratings are on ten different traits or characteristics; and they are made in terms of A, B, and C. The names of the ten traits are reliability, industry, initiative, tact, attitude, analytical ability, aptitude, enthusiasm, personality, decision.

Since the men are transferred each month and rated by different foremen, several ratings in each trait are recorded. By combining these ratings a more discriminating rating on each man of the group being studied was obtained. That is, the values A, B, and C were transmuted into the values 2, 1, and 0, respectively; and by combining and averaging these ratings, fractional values between these integers were obtained, such as 0.8 or 1.3 or 1.7 as a man's average rating. Correlations of these shop ratings with other data on the men, are given in Table IV.

TABLE IV.
Correlations of Shop Ratings with Other Criteria.

Subjects	Number of cases	Correlation (r)
Shop ratings with estimated intelligence, committee's rating	95	.0
Shop ratings on analytical ability with estimated intelligence, committee's rating	94	.0
Shop ratings with Bureau Test VI scores	58	.0
Shop ratings on analytical ability with Bureau Test VI scores	56	.0
Shop ratings with ratings at interview for employment	27	.0
Shop ratings on analytical ability with ratings on intelligence at interview for employment	26	.0
Shop ratings on personality with ratings on personal qualities at employment interview	27	+.25
Shop grades with shop ratings	74	.0

From these correlations we conclude that the ratings made by the foremen on the men working under them only one month, are very unreliable, and really indicate nothing. Doubtless, this unreliability cannot all be charged to the inability of the foremen to judge the men on some of these traits; but the method of rating, of recording these ratings, and of combining ratings by different foremen, makes them incomparable and unreliable. In the shop and the Educational Department, the interpretations of analytical ability and of aptitude are practically the same as that which is called general intelligence by the psychologists. The ratings on analytical ability were correlated with estimated intelligence and with test scores in the hope that a significant positive correlation would be found, but there was none. One exception to the lack of positive correlation is the small correlation between personality as judged by foremen and personal qualities

as judged by the representatives of the company who rated the men at the interview for employment. It seems reasonable to expect such a positive correlation; for it is doubtless the general personality which influences both the interviewer's and the foreman's rating on a man in most of the traits, in much the same way.

TABLE V.

Some Intercorrelations of Ratings by Foremen on Traits of Engineers.

	Number of cases	Correlation (r)
Reliability with industry	117	+.66
Initiative with tact	113	+.66
Initiative with enthusiasm	107	+.42
Analytical ability with aptitude	102	+.72
Analytical ability with personality	104	+.26
Enthusiasm with personality	106	+.57

Correlations between the ratings on some of the traits were computed. The highest correlation found is between analytical ability and aptitude, + .72, which seems *a priori* reasonable. The next highest correlation is (r = +.66) between reliability and industry, which might be expected; but there is the same correlation between tact and initiative, two traits which *a priori* we should judge would tend to be found in somewhat opposite types of individuals. The lowest correlation is between analytical ability and personality, which does not seem unreasonable.

To discover whether the ratings on the ten different traits could be of any value in differentiating the engineers, the average of the ratings on each trait for each group was computed. These averages are shown in Diagram 2. The curves tend to follow each other very closely. Also, it was found in most of the ratings that if a man was rated high in one trait, he was rated comparatively high in another. Personality and enthusiasm differentiate the groups most widely. Frequency column diagrams, Diagrams 3, 4, 5, and 6, show that the ratings in these two traits and in tact and initiative, tended to separate the sales engineers, and the work management engineers from the other engineers. By combining the ratings in these four traits we get a very definite differentiation of the four groups of engineers. See Diagram 2. It seems evident that people on coming in con-

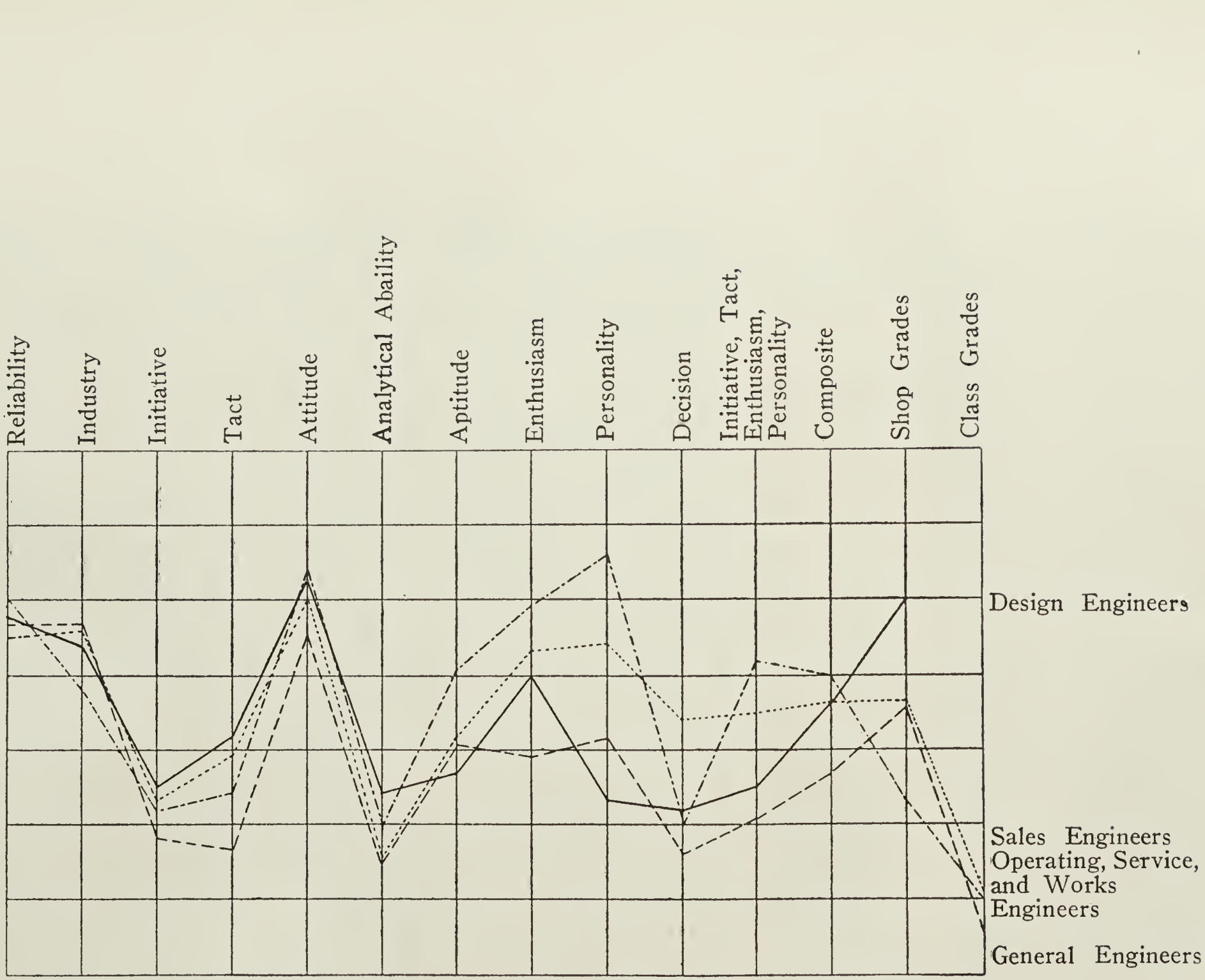

Diagram 2. Averages of Foremen's Ratings and Grades and of Instructors' Class Grades for Each Group of Engineers.

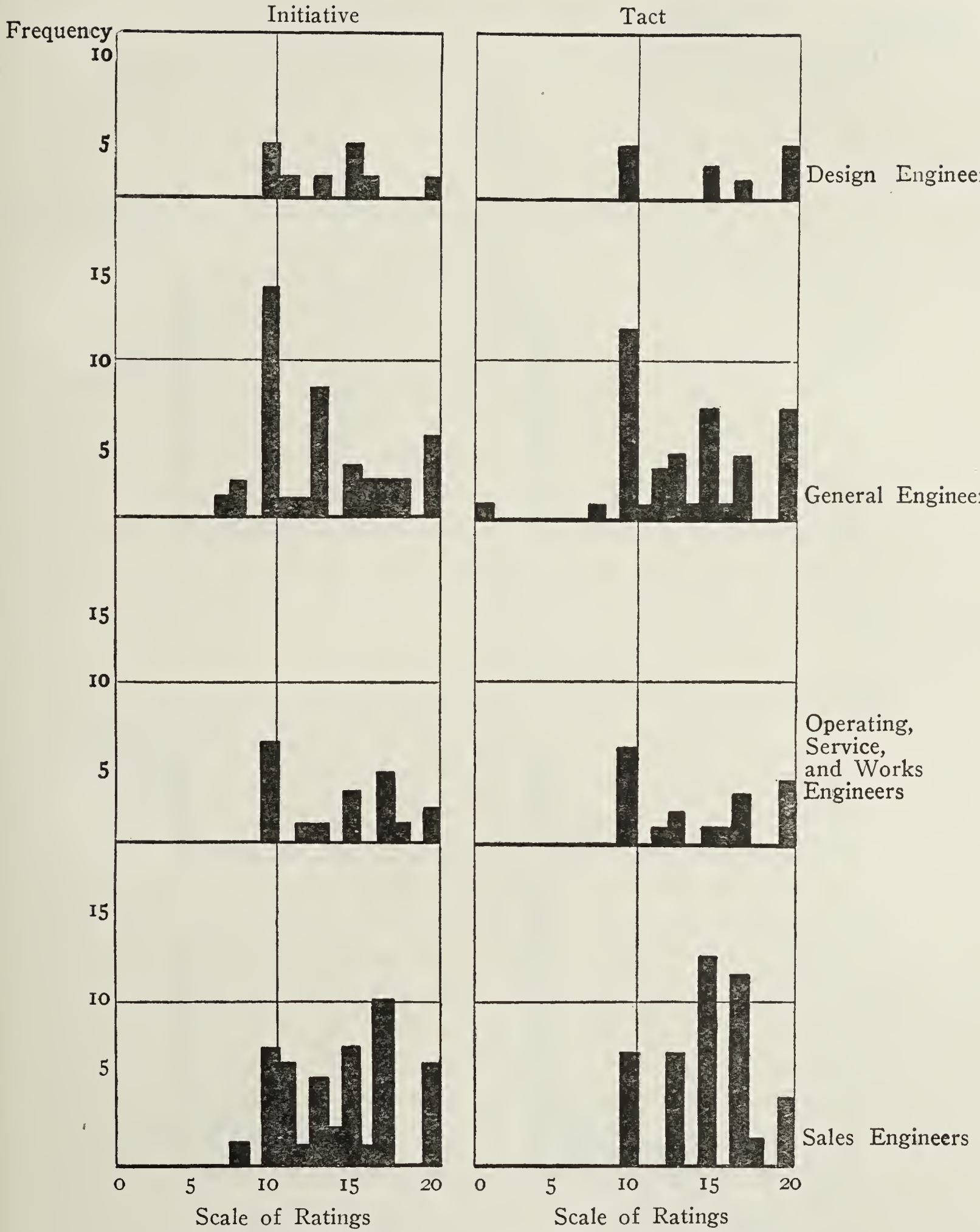

Diagram 3. Ratings on Initiative by Foremen of Student Engineers Classified by Occupation.

Diagram 4. Ratings on Tact by Foremen of Student Engineers Classified by Occupation.

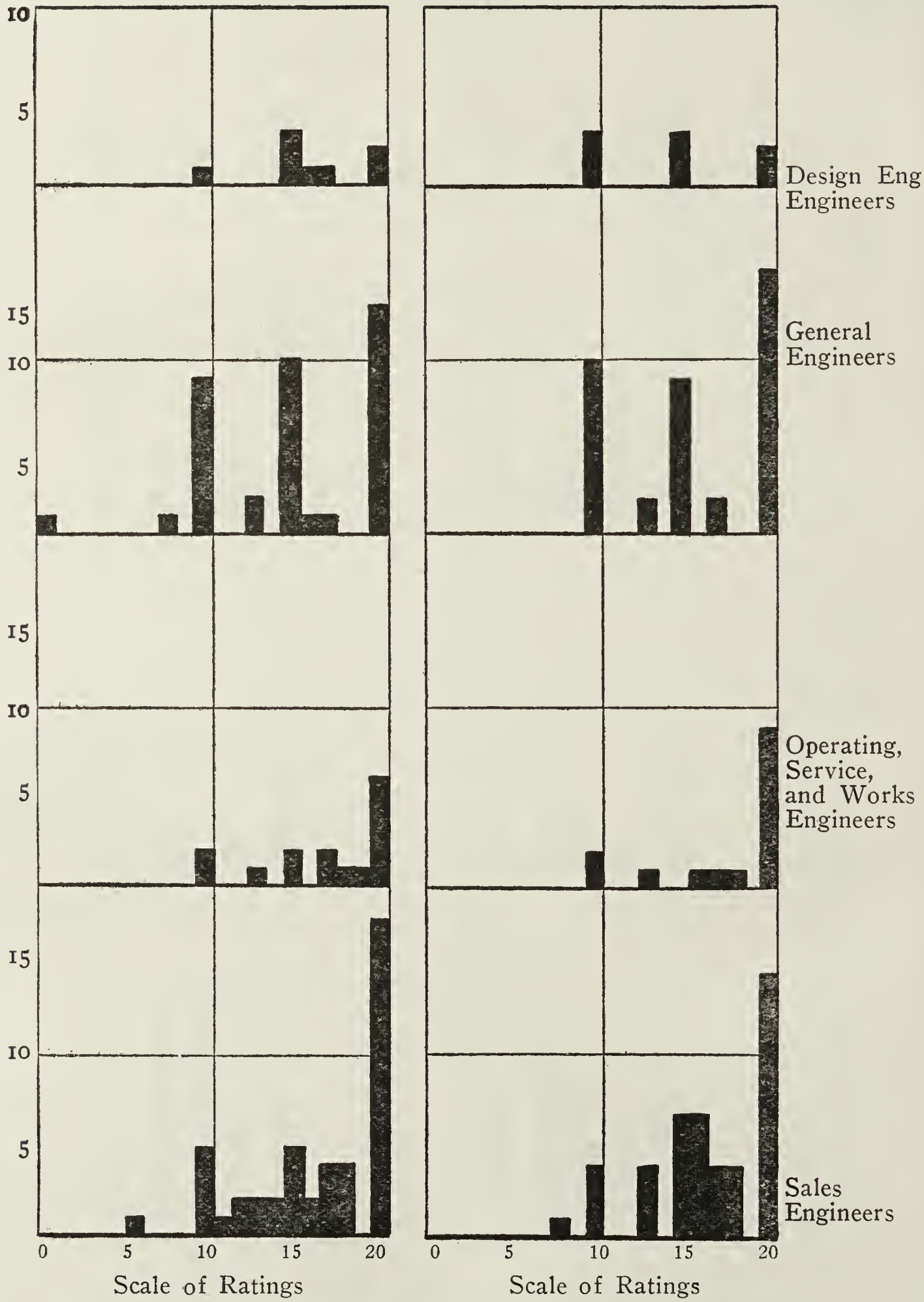

Diagram 5. Ratings on Enthusiasm by Foremen of Student Engineers Classified by Occupation.

Diagram 6. Ratings on Personality by Foremen of Student Engineers Classified by Occupation.

tact with the different groups of engineers sense a difference in the personal traits of these men; but definite analysis and measurement of this difference is difficult in any particular individual.

VII. A Study of Rating Scales

For differentiating sales engineers from other engineers, it is probably true that the personal qualities aside from intelligence are more important. This has been recognized in the attempt to estimate these qualities as a whole without a rating scale when a man was being considered for any particular work. There are at present no psychological tests for measuring these qualities, but there are refined methods of making estimates or ratings. The rating scale is a tool or means for carrying out such a more accurate method. Its value as a measure of various traits depends upon the standards which it sets up as measuring rods, and its accuracy depends upon the definiteness of these standards.

1. *Principles of a Rating Scale*

Employers have always tried to estimate the value of a man as a whole, considering his qualities altogether without the use of a rating scale. Great differences in the estimates made by different persons on the same man have shown this to be an uncertain method. The man's qualities must be separated and rated by themselves; for if they are not, the estimator is likely to let his prejudices consider only one prominent quality and let them bias his judgment so as to neglect all other qualities. For example, a foreman or supervisor may have an intense dislike for one of his workers because the worker has a disfigured face, and unconsciously the foreman overlooks the man's other good qualities. However, when the rating scale calls for a consideration of these qualities separately, he is forced to realize that the worker may be intelligent, industrious, skillful, and coöperative. After the foreman is led to face the facts in this way, he must admit that, after all, the man has good points that are valuable in a workman. On the other hand, the foreman may have to admit that he has been overlooking another workman's laziness and lack of skill because this man was always good-natured and so-

ciable. Moreover, the fact that these ratings must be signed and given in black and white to a superior who can check them, leads the foreman to consider sources of inefficiency in his workers. It also makes him more careful and fair-minded in his judgments of his men.

We can then lay down as the first principle of the rating scale that: (1) Instead of trying to estimate a person's ability as a whole for doing any particular work, this ability is analyzed into component essential abilities or traits, and each trait is rated independently of the others. The traits selected should be the most important for success in the particular situation. It is much better to have a few traits that are really essential and critical for a worker's success than to have ratings on many traits, some of which are relatively unimportant. That is, it is much better to concentrate on a few important qualities and have ratings on these made and really used than to have a system so elaborate that it breaks down from its own size and complexity. The traits included in the rating scales discussed here were selected for rating men under certain conditions for a definite purpose. Anyone using this scale would have to consider these traits for their particular purpose in the light of the principles stated here.

The reliability of a rating scale as a measure of various traits depends upon the standards, particularly the definiteness of the standards which it sets up as measuring rods. Therefore, other principles for making an accurate rating scale are to be observed; and the next principle is: (2) the different traits determined upon must be really different and as distinct from each other as possible. They must be supplementary to each other with the minimum of indefiniteness and overlapping.

(3) For rating a person in any trait, the person doing the rating must be acquainted with the one to be rated, and have more or less dependable facts for making a decision. When an employee asks for a promotion or transfer, the employment manager cannot rate the employe in *coöperation* or in *industry;* but the worker's previous foreman probably could. On the other hand the employment manager might be a better judge of the

applicant's *appearance and manner* in considering him for transfer to the office or some place where he would meet the public.

(4) The traits must be as sharply defined as possible so that different people doing the rating will rate the same trait. In naming and defining traits, use terms which are more or less common and have, as nearly as possible, universally the same meanings accepted by everybody and the minimum chances of ambiguity and misunderstanding.

(5) For rating an individual in a trait, the basis of comparison used as a scale should be as concrete and as familiar as possible. To provide this condition, the person to be rated is compared in regard to a particular trait with other well-known persons who differ in the extent to which they have that particular trait. That is, a foreman, in rating a man, should compare him with men who are doing the same kind of work under similar circumstances; and the foreman must be well acquainted with the traits and qualifications of the men.

(6) Where more than one individual is to be rated in more than one trait, more comparable results are obtained by rating all individuals in one trait before rating any of the individuals in any other trait.

(7) More reliable results are obtained by having a person rated by more than one person, ratings by three persons being recommended if it is possible to get them. These ratings should be made independently and then averaged. A revision of one rating by another person is not so accurate as a combination of two ratings made separately.

2. *Evaluation of the Rating Scale Used, Entitled, "Rating by Interviewer"*

With the above principles in mind, a study was made of the results of the scale already in use by the Company, which is entitled *Rating by Interviewer* (p. 24). The purpose was to check the value of such a scale and the particular selection of traits. The scale was used with only thirty-one students, but the number is sufficient to give results that are significant, though by no means final. Table VI. shows the correlations between the

RATING BY INTERVIEWER

THIS SIDE NOT TO BE WRITTEN UPON BY APPLICANT

			Remarks
I. Physical qualities—Physique, bearing, neatness, voice, energy, endurance. (Consider how he impresses men in the above respects.)	Highest	20	
	High	16	
	Average	12	
	Low	8	
	Lowest	4	
II. Intelligence—Accuracy, ease in learning, ability to grasp the point quickly, to express himself clearly, and to estimate a new situation.	Highest	20	
	High	16	
	Average	12	
	Low	8	
	Lowest	4	
III. Leadership — Initiative, force, decisiveness, tact, helpfulness, ability to inspire men and to win their loyalty and cooperation.	Highest	20	
	High	16	
	Average	12	
	Low	8	
	Lowest	4	
IV. Personal qualities—Industry, dependability, loyalty, readiness to shoulder responsibility for his own acts, freedom from conceit and selfishness, readiness and ability to cooperate, and charm of personality, breadth of conceptions.	Highest	20	
	High	16	
	Average	12	
	Low	8	
	Lowest	4	
V. General Value to the Company—Special talent (commercial, mechanical, mathematical, executive), gets results, works well in an organization. Special interest in W. E. & M. Co. Previous training and experience. Will develop.	Highest	20	
	High	16	
	Average	12	
	Low	8	
	Lowest	4	

Recommendations of Professors and Instructors—

REPORT OF INTERVIEWER

1. General impressions

2. Work best suited for

3. Acceptance (write Yes or No)

4. Next action promised by interviewer

Signed _____ Date _____
Interviewer

original interview ratings, the tests, and the ratings made by the Educational Department committee one year later. Also the relation between each trait and the total of ratings on each trait, and the intercorrelations between traits is shown. All correlations are positive.

TABLE VI.

Correlations of Ratings by Interviewers with Other Criteria.

	Number of cases	Correlation (r)
Interviewers' composite ratings with estimated intelligence, committee's rating	31	+.65
Interviewers' composite ratings with Bureau Test VI scores	18	+.58
Interviewers' ratings of intelligence with Bureau Test VI scores	18	+.57
Interviewers' ratings of intelligence with estimated intelligence, committee's rating	31	+.22
Interviewers' composite ratings with shop ratings	27	.0
Interviewers' ratings of intelligence with shop ratings on analytical ability	26	.0
Interviewers' ratings of personal qualities with shop ratings on personality	27	+.25
Interviewers' composite ratings with technical school grades	21	+.22
Interviewers' composite ratings with their ratings of leadership	32	+.80
Interviewers' composite ratings with their ratings of personal qualities	32	+.79
Interviewers' composite ratings with their ratings of physical qualities	32	+.73
Interviewers' composite ratings with their ratings of general value to company	32	+.68
Interviewers' composite ratings with their ratings of intelligence	32	+.68
Personal qualities with general value to company	32	+.67
Personal qualities with leadership	32	+.59
Intelligence with general value to the company	32	+.48
Leadership with general value to the company	32	+.47
Leadership with physical qualities	32	+.46
Personal qualities with physical qualities	32	+.45
Intelligence with personal qualities	32	+.44
Physical qualities with general value to company	32	+.43
Intelligence with leadership	32	+.40
Intelligence with physical qualities	32	+.23

The interviewers' ratings of intelligence agree much better with the scores of the psychological test for intelligence, $r = +.57$, than they do with the committee's later estimate of intelligence, $r = +.25$; but since the interviewers' ratings of intelligence correlate comparatively low with their composite ratings including other qualities, $r = +.68$, and since the composite

ratings have high correlation with the later estimate of intelligence by the committee, r = +.65, we might take these facts as evidence that qualities other than intelligence have unconsciously been included in the later ranking of the men.

The most important correlations to consider in relation to the rating scale, are those of Personal Qualities, which correlate, with General Value to the Company, r = +.67, and with Leadership, r = +.59. These correlations are entirely too high between traits which according to the best principles should be disparate traits. These high correlations are undoubtedly due to the indefinite and too inclusive definitions of these traits. Therefore I have worked to make these traits more definite and exclusive in the revised definitions or descriptions of them. The revised forms are seen in the Interviewer's Master Scale, discussed later. Some of the other traits have had the definitions slightly changed to make the same improvement toward definite unit traits which could be more accurately rated.

3. *The Revised Form of Interviewer's Rating Scale*: *The Interviewer's Master Scale*

Not only were these results considered in the revision, but the whole aim was to make the rating scale best adapted to select men for the particular lines of work to be done for the particular Company. From the occupational description or information that had been obtained concerning each line of work to which a graduate engineer is later assigned, I made an analysis of what qualifications or traits are essential for success in each line of work or specific occupation. The traits for each occupation were listed separately. Then to enrich this list and to be sure that no traits were omitted, comparison was made with the list of traits already being used by the Westinghouse interviewers and also with the traits considered in a rating made later in the Educational Department. Also all other available rating scales, including the Bureau Scale for Salesmen, and the Army Officer Rating Scale, were compared with the list of traits. Finally, Mann's Study of Engineering Education, and Davenport's Trait Book, which lists several hundred traits, were examined for suggestions

of traits. From the final nine lists of traits (one list for each occupation), selection was made for the traits common to all lists and those which were similar were grouped under one name of an essential trait. Then selection was made of those traits which were not common and which tended to differentiate the occupations. For making the scales to be used in the first selection and employment of applicants or prospective applicants, the common and the differentiating traits were combined. For constructing the scales which were to be used later in separating the men, the differentiating traits were emphasized.

The first work in preparing rating scales was to revise the scale already in use, called the *Interviewer's Rating,* shown on page 24. As the revisions were simply in the definitions of the traits, these may be seen in the form for the *Interviewer's Master Rating Scale,* which was prepared. This Master Scale is the standard or measuring rod with which the senior engineer is compared and rated by the interviewer. The form of this is shown on page 28. The method of making and using the scale is explained in the following section.

4. *Instructions to Interviewers for Rating Senior Engineers*

Significance of the Rating Scale.

(1) The rating of a senior engineer is a numerical expression of the degree in which he possesses five qualifications considered essential in a Westinghouse engineer, namely: (I.) Physical Qualities, (II.) Intelligence, (III.) Leadership, (IV.) Social and Personal Qualities, (V.) General Value to the Company. The rating is made by comparing him in each of these respects with engineers who are now employed in the Company. Each rater makes his own scale, using the Interviewer's Master Rating Scale. Proper rating is largely dependent on the possession of an accurate Master Rating Scale. Do not start to prepare your scale until you can give at least thirty minutes to it.

INTERVIEWER'S MASTER SCALE

(To be filled out by all interviewers in committee together, for use as a standard in rating each applicant.)

Have before you the names of at least twenty-five of your engineers and salesmen with whom you all are well acquainted. Include in this list men that rank highest, lowest and intermediate in Physical Qualities; men that rank highest, lowest and intermediate in Intelligence; and similarly in Leadership, in Social and Personal Qualities, and in General Value to the Company.

I. PHYSICAL QUALITIES

Disregard every characteristic of each of your engineers and salesmen except their physical qualities. Consider *physique, bearing, neatness, facial expression, voice, charm of appearance and manner, energy, and endurance.* (Consider how he impresses men in such qualities.)

Highest Mr.....20
High Mr.....16
Middle Mr.....12
Low Mr..... 8
Lowest Mr..... 4

II. INTELLIGENCE

Consider *common sense, judgment, ability to grasp the point quickly, to express himself clearly, and to estimate a new situation.* On the basis of intelligence make a selection of five of your men as in Number I above,—highest, lowest, middle, high, low. These five need not be the same as those in Number I.

Highest Mr.....20
High Mr.....16
Middle Mr.....12
Low Mr..... 8
Lowest M r..... 4

III. LEADERSHIP

Consider *force, decisiveness, enthusiasm, and ability to inspire men and to win their loyalty and cooperation.*

Highest Mr.....20
High Mr.....16
Middle Mr.....12
Low Mr..... 8
Lowest Mr..... 4

IV. SOCIAL AND PERSONAL QUALITIES

Consider *conversational ability, tact, freedom from conceit and selfishness, readiness to shoulder responsibility for own acts, readiness and ability to cooperate, sociableness, and congeniality.*

Highest Mr.....20
High Mr.....16
Middle Mr.....12
Low Mr..... 8
Lowest Mr..... 4

V. GENERAL VALUE TO THE COMPANY

Consider *previous training and experience showing interest and adaptability,* (commercial, mechanical, mathematical, executive) *special interest in W. E. & M. Co. and professional attitude.*

Highest Mr.....20
High Mr.....16
Middle Mr.....12
Low Mr..... 8
Lowest Mr..... 4

How to Make the Master Scale.

(2) Write on small slips of paper the names of from 12 to 25 engineers who have passed through the Educational Department within the previous five years. They should be men with whom you are well acquainted, and of whose degree of success you have some definite knowledge. Include some whose qualifications are extremely poor as well as those who are highly efficient. If these

names do not include all the grades for each of the five qualifications, others may be added.

(3) Look over your names from the viewpoint of Physical Qualities only. Disregard every other characteristic of each man except the way in which he impresses men by his physique, bearing, neatness, voice, charm of appearance and manner, energy and endurance. Arrange the names on the slips of paper in order from highest to lowest on the basis of the Physical Qualities of the men. Select that engineer who surpasses all the others in this qualification and enter his name on the line marked Highest under Physical Qualities on the Interviewer's Master Scale. Then select the one who most conspicuously lacks these qualities and enter his name on the line marked Lowest. Select the man who seems about half way between the two previously selected and who represents about the general average in Physical Qualities; and enter his name on the line marked Middle. Select the engineer who is halfway between middle and highest, and enter his name on the line marked High. Select the one who ranks halfway between middle and lowest, and enter his name on the line marked Low.

(4) In the same manner make out scales for each of the other four qualifications (Intelligence, Leadership, Social and Personal Qualities, and General Value to the Company).

(5) Each engineer whose name appears on the Scale should be one who exhibits clearly and distinctly the qualification and the degree of the qualification for which he has been chosen.

(6) The names for Highest and Lowest on each section of the Scale must represent extreme cases. The names for the Middle should be that of an average engineer, halfway between extremes. High and Low should be halfway between the Middle and the extremes. An even gradation of merit is important.

(7) In making or using any section of the Scale, consider only the qualification it covers, totally disregarding all the others.

How to Use the Scale.

(8) Rate your senior student engineer for Physical Qualities first. Consider how he impresses men by his physique, bearing,

neatness, voice, charm of appearance and manner, energy, and endurance. Compare him with each of the five men in Section I. of your Master Rating Scale, and give him the number of points following the name of the man he most nearly equals. Check this number under Physical Qualities on your blank entitled Interviewer's Rating. If he falls between two men in the Scale, give him a number, accordingly, between the numbers of these two names in the Scale.

(10) Rate the engineers in a corresponding manner for each of the other four essential qualifications.

(11) In rating, make a *man-to-man comparison* of the man with the men whose names appear on your Scale—never in terms of numbers directly. *Disregard the numerical equivalent until you have made these concrete comparisons.*

(12) When rating several engineers, rate all of them on each qualification before adding the total for any one.

(13) This is not a percentage system and you should not allow yourself to fix in mind any particular number of points you think the engineer ought to get.

(14) The total rating for an engineer is the sum of the ratings you give him in the five separate qualifications.

5. *College Instructor's Rating Scale.*

There are many traits desirable in an engineer which can not be rated with any reliability from a brief interview with a senior student. However, an instructor having had the student in his classes and knowing of his college activities, could rate the man on definite objective criteria. It was thought at first that the *College Instructor's Rating Scale* (see page 31) should have entirely different traits; but in order to reduce the possibilities of confusion to the minimum and to make the combination of the ratings of the two scales easy, practically the same names of traits are used on both scales. The ratings from the Instructor's Rating Scale can be checked just to the left of the interviewer's ratings on the present form, Rating by Interviewer. However, it is *important that the interviewer make his rating independently*

COLLEGE INSTRUCTOR'S RATING SCALE

Will you please rate the student named below for the traits indicated, keeping in mind employment after graduation. Give the rating independently without consulting others. This rating sheet is to be returned to the Bureau of Recommendations without delay. Do not rate any student whom you have not had in class at least one term.

Name .....

Among the members of the average senior class in this student's COURSE AND SCHOOL, in which fifth would this student rank in each trait? Indicate the rank in each trait by placing a check (V) at the proper height in each column, grading the student as finely as you can. The traits are described as follows:

I. *Appearance and Manner.*—Consider physique, bearing, neatness, facial expression and voice. (Consider how he impresses men in such qualities.)

II. *Intelligence.*—Consider accuracy, promptness, ease of learning, ability to grasp the point quickly and to express himself clearly, and ability to estimate a new situation and to get desired results professionally.

III. *Leadership.*—Consider initiative, self-reliance, enthusiasm, tact, and ability to inspire men and to win their loyalty and cooperation.

IV. *Personal Qualities.*—Consider honesty, reliability, spirit of service, sense of responsibility for his own acts and moral stamina.

V. *Professional Interest.*—Consider industry, energy, perseverance, and conscientious application to work.

	Appearance and Manner	Intelligence	Leadership	Personal Qualities	Professional Interest
Highest Fifth					
Second Fifth					
Middle Fifth					
Fourth Fifth					
Lowest Fifth					

To aid further the Bureau of Recommendations, please indicate, if possible, THE SPECIFIC KIND OF WORK for which this student is best fitted.

.....

.....

SPECIFIC WORK

In this SPECIFIC WORK how would you rate this student among the members of the average Senior Class in this student's COURSE AND SCHOOL? Indicate your opinion by a check (V) at the proper height in the column to the right.

Highest Fifth: _____

Second Fifth: _____

Middle Fifth: _____

Fourth Fifth: _____

Lowest Fifth: _____

(Use the other side of this sheet for remarks concerning the student.)

and before he sees the instructor's ratings or copies them on his sheet. Then an average of the two can be made.

The traits to be rated are not defined the same on the two scales. They should be rated from two different viewpoints, namely from what the instructor's acquaintance and observation reveals to be the actual rating of the trait, and from the first impression which the individual gives other people regarding the trait, as shown by the interviewer's rating. With the background and viewpoint of the instructor differing from that of the interviewer, the ratings will supplement and balance or check each other. Professional interest or industry and professional ability can be judged better by the college instructor; but General Value to the Company can be judged better by the Company representative.

The instructor cannot be expected to prepare a scale, so he is asked to rate the student in terms of fifths of the average senior class. The interviewers, however, should prepare an Interviewer's Master Rating Scale, and by mental comparison of students with the men named on this scale, that is, a man-to-man comparison, a rating can be given to that student for each trait, and then be entered on the form, *Rating by Interviewer.*

6. *Shop and Class Rating Scale*

The unreliability of the shop ratings made by the foremen, and of the class and shop grades, has already been discussed in Chapter VII, entitled "Evaluation of Grades and Ratings Given During Training in the Educational Department of the Industrial Firm." It was stated there that the causes of this unreliability were evidently due to the lack of adequate definitions of the traits, to the lack of common understanding by the foremen of the meaning of the names of the traits, to the lack of a standard, scale, or measuring rod with which to compare the persons being rated, and to the arbitrary method of recording and reporting the ratings. In order to obviate or at least minimize these causes of unreliability of the ratings, the *Shop and Class Rating Scale* was prepared. It is intended that each foreman and instructor shall rate each student engineer under them once each

SHOP AND CLASS RATING SCALE

Name ..... Section.....

Rate the man named above in the traits indicated. The traits are defined and described on the other side of this sheet.

Among the GRADUATE ENGINEERS whom you have known in this particular work that you have charge of, in which fifth,—highest, second, middle, fourth, or lowest, should this man rank in each trait? Indicate the rank in each trait by placing a check (V) at the proper height in each column, grading the man as carefully as you can.

	Intelligence	Co-operation	Industry	Leadership
Highest Fifth				
Second Fifth				
Middle Fifth				
Fourth Fifth				
Lowest Fifth				

In what work does this man excel?.....

.....

In what is he deficient?.....

.....

Signed ..... Date .....

NOTE:—Send to the Educational Department.

DEFINITIONS OF TRAITS OR QUALITIES TO BE TREATED

I. INTELLIGENCE.—Consider aptitude, ability to learn, common-sense, judgment, and ability to grasp the point, to express himself clearly, and to deal with a new situation.

II. COOPERATION.—Consider tact, courtesy, fair-mindedness, sociability, and ability to get along with other men and to fit into the organization.

III. INDUSTRY.—Consider energy, perseverance, conscientious application, reliability, interest, enthusiasm, and loyalty.

IV. LEADERSHIP.—Consider initiative, aggressiveness, force, decisiveness, and ability to influence men and win their loyalty and cooperation.

month on this *Shop and Class Rating Scale.* The ratings are to be sent to the Educational Department office, where they are to be combined with the other data on the student engineers.

For differentiating the sales engineers from the other engineers certain traits considered essential for sales engineering ability can be selected and the total rating on these traits for each graduate engineer will show his probable aptitude for sales engineering. To take advantage of data previously obtained, ratings on certain traits which differentiate the graduate engineers, for example traits desired in a salesman, might be se-

lected from the other rating scales and combined with these. For example, ratings on leadership, social and personal qualities, and physical qualities might be taken from the *Interviewer's Rating Scale* and from the College *Instructor's Rating Scale.*

VIII. Survey and Evaluation of Interests as Criteria for Vocational Placement

1. *The Significance of Interests*

The technical school grades, the grades and ratings on the work of the men during training in the Educational Department, and the results of the tests discussed in the next section, indicate that the engineer cannot be differentiated for the different kinds of work by general intelligence or mental alertness. Men with equal mental ability are found in all the lines of work. Success of a certain person in a particular line of work is evidently due to general intelligence or mental ability directed in a particular line by interests. However, it is probably true that the interests are based on a particular ability or group of abilities which makes activity and achievement in a particular line of work possible and interesting. Leaving the question of general intelligence and particular abilities to be discussed in the next section, we consider here the interests themselves without raising the question of what causes them.

After the man has a definite strong interest in any line of work or activity, this interest, motivation, or whatever it may be, should be taken advantage of. It is difficult to discover just what the interests are, and often the graduate student engineers cannot decide themselves what work they should prefer. In order to make possible the planning and direction of their training, the custom has been to ask them to indicate their choice of work at the end of two months' work in the Westinghouse Company, during which time they have been doing various kinds of work in the shop under the supervision of the Educational Department. To help them make this choice, and to help the executives know more definitely what this choice is, the form, *Record of Interests,* which is a kind of rating scale, has been prepared.

2. *Method of Using the Record of Interests*

With the exception of Section II., entitled Choice of Other Occupations, the whole of the Record of Interests blank may appear to add nothing new to the ordinary questions often asked when attempting to place a man. Nevertheless, there is a definite attempt to get these facts tabulated in usable form. Each class of information or facts concerning the man is considered separately, and a definite unmixed judgment is made on that phase of the man's interests and qualifications. Thus the *Record of Interests* is really a rating scale of interests. The judgments

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RECORD OF INTERESTS

Prepared by B. V. Moore, Research Fellow, Expressly for the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pennsylvania.

To the Graduate Student Engineer:

Answer the questions, and fill in the blanks as accurately as you can. None of your statements here commit you to any particular assignment. This record enables us to help you find the most suitable position in the Westinghouse organization.

I. PREVIOUS VOCATIONAL INTERESTS

1. In your college work which type of work or subjects interested you most? Rank the types of work below in order of preference, numbering the best liked (1), the next best (2), and so on to the least liked, which you number (9).

( ) English	( ) Field Work	( ) Testing
( ) Economics	( ) Shop Work	( ) Laboratory
( ) History	( ) Drawing or Draft'g	( ) Mathematics

2. Did you ever construct or build any mechanical or electrical toy, apparatus, or machines of any kind before you entered college?
( ) No ( ) Yes
3. What were the things you made?.....
.....
4. Did you make these things chiefly because you wanted the things themselves or because you enjoyed making them?
( ) Wanted the things. ( ) Enjoyed making them.
5. In making the toy, apparatus, or machine, did you make it like another, or did you design it yourself?
( ) Made it like another. ( ) Designed it myself.
6. Did you ever work as a salesman or clerk in a store, sell in a house to house canvass, or work as a salesman in any way?
( ) Yes ( ) No
7. What do you consider to be the most responsible position that you have ever held?
.....
8. In all your practical experience, including remunerative work during vacations, which work or particular job have you liked best?
.....
9. Why did you choose engineering as your profession?
.....

II. CHOICE OF OTHER OCCUPATIONS

Disregarding all your training and education and all differences in compensation and social standing of the following occupations, **consider only your interest and satisfaction in working at each of the following occupations represented.** Check with a plus (+) the ten kinds of work which you would most prefer to do; and check with a minus (—) the ten which you would dislike or least like to do.

( ) Architect	( ) Machinist
( ) Automobile repairman	( ) Newspaper reporter
( ) Automobile salesman	( ) Pattern-maker
( ) Bank cashier	( ) Private secretary
( ) Carpenter	( ) Purchasing agent
( ) Draftsman	( ) Real estate agent
( ) Editor of popular magazine	( ) Research worker in physics
( ) Hotel keeper or owner	( ) Stockbroker
( ) U. S. Governm't astronomer	( ) Toolmaker
( ) Lawyer	( ) Watchmaker

III. AVOCATIONAL INTERESTS

1. What do you like to do as an avocation, hobby, or sideline?
   .....
2. What form of recreation or entertainment do you enjoy most in the evening after a day of study or work?
   .....
3. What sports do you enjoy most as a participator?
   .....
4. What professional and business magazines do you read regularly?
   .....
   .....
5. Have you participated in any of the following extra-academic activities:

Student debating	( ) Yes	( ) No
Dramatics	( ) Yes	( ) No
Student paper or annual book	( ) Yes	( ) No
School politics	( ) Yes	( ) No
Ever captain of a team	( ) Yes	( ) No

IV. SOCIAL INTERESTS

1. Name the social clubs, fraternities, and organizations to which you belong.
   .....
   .....
2. Have you ever held any important office in any of these organizations?
   ( ) Yes ( ) No
3. How many times have you made an after-dinner talk?.....
4. While you were in college did you prefer to live with a roommate or did you prefer to room alone?
   ( ) Roommate ( ) Room alone
5. Do you usually have a good time at smokers, conventions, and other gatherings of men?
   ( ) Yes ( ) No
6. Excluding engineering magazines, name three magazines which you enjoy reading.
   .....

V. INTERESTS OF RELATIVES

1. What is or was the occupation of your father?.....
2. What were the occupations of your:
   (a) Father's father?.....
   (b) Mother's father?.....
3. What are occupations of your brothers?
   .....
   .....

VI. TECHNICAL INTERESTS IN WESTINGHOUSE ORGANIZATION AND ITS WORK

1. Considering all aspects of each line of work as you have become acquainted with them here so far, decide which particular kind of work you would prefer to make your life occupation. Give this line of work a rank or score of (1). Give your second choice a rank of (2), and so on, giving your least desirable choice a rank of (4).

( ) Sales
( ) Works Management
( ) General Engineering
( ) Design Engineering

2. Considering the content or subject-matter of the work itself, which subject or courses in the W. E. & M. Co. Educational Department have interested you most? Write them in order of preference, the best liked first.

(1)
(2)

3. Check with a plus (+) the following lines of work which you think you would choose as your work in the Westinghouse organization. Check with a minus (—) those which you think you would not choose as your work in the Westinghouse organization.

( ) General Engineering
( ) Transformer Engineering
( ) Control Engineering
( ) Switchboard Engineering
( ) Industrial and Railway Motor Engineering
( ) Railway Equipment Engineering
( ) Material and Process Engineering
( ) Research Engineering
( ) Detail Engineering
( ) Power Engineering
( ) Industrial Sales
( ) Supply Sales
( ) Power Sales
( ) Railway Sales
( ) Marine Sales
( ) Stocker Sales
( ) Foreign Sales
( ) Production
( ) Time and Motion Study
( ) Inspection
( ) Cost Accounting
( ) Maintenance
( ) Operating
( ) Dynamo Test
( ) Transformer Test
( ) Large Industrial Motor Test
( ) Small Industrial Motor Test
( ) Detail Test
( ) Farm Lighting Equipment Test

(Do not write in the space below)

	I. Vocational	II. Other Occ's	III Avocations	IV. Social	V. Relatives	Technical
Design						
General						
Oper'g Service						
Works						
Sales						

REMARKS:

or ratings are made by a man or by men who are intimately familiar with the lines of work and opportunities open to the student engineers. With these lines of work in mind, the one doing the rating considers the man's answers to the questions of Section I., entitled Previous Vocational Interests, and decides whether the facts appearing there indicate that the man is qualified by his fundamental interests and experience to be a design engineer, a general engineer, a works management engineer, an operating engineer, a service engineer, or a sales engineer. Then turning to the *Summary* on the last page of the *Record of Interests,* the rater places a check ($\surd$) in the proper rectangular blank space under the column head, I. Vocational. Each section is considered separately in this way, a judgment is made from each class of facts, and a check is made in the proper square of each column of the *Summary.* By connecting the check marks with straight lines, a curve is obtained which shows the general tendency of the interests of the man, whether fitting him for design, general, works management, operating, service, or sales engineering. This gives a definite and permanent graphic record of pertinent facts concerning each man. Instead of a hazy vacilating general impression of the man, there is a tangible analyzed judgment of him. By keeping this on file and easily available, it is possible to have always before the executive considering the man, a careful record of previous judgments.

3. *Evaluation of Specific Questions in the Record of Interests*

To test out the value of the *Record of Interests,* it was filled out by sixty-four adults in one class and sixty in a second class of the School of Insurance Salesmanship at the Carnegie Institute of Technology. The results for each Insurance Salesmanship class are tabulated separately in order that the two sets of data will be a check on each other, and their agreement be some measure of their reliability. Later the *Record of Interests* was filled out also by thirty Westinghouse design engineers and thirty sales engineers, none of whom had been with the Company less than a year nor more than five years. The following table shows the results obtained for some of the chief questions.

Each section is discussed later and evaluated separately in the light of the results obtained.

TABLE VII.

Results Obtained from Record of Interests of Insurance Salesmen, Design Engineers, and Sales Engineers

Insurance Salesmen

No. of Question	Question	Answered (Yes) First Class	Answered (Yes) Second Class	Answered (No) First Class	Answered (No) Second Class	No. of Cases First Class	No. of Cases Second Class
I. 2.	Constructed toy?	25%	40%	75%	60%	55	62
I. 4.	Wanted toy?	27%	53%	73%	47%	15	15
I. 5.	Copied Design?	69%	47%	31%	53%	13	15
I. 6.	Had sold articles?....	84%	81%	16%	19%	62	52
III. 5.	Student Debating? ...	51%	56%	49%	44%	51	45
	Dramatics?	45%	48%	55%	52%	53	46
	Student paper or book?	40%	52%	60%	48%	53	46

I. 1. Rank of Choice of School Studies or Subjects.

	Average Rank Given First Class	Average Rank Given Second Class	Number of Cases First Class	Number of Cases Second Class
English	3.07	3.23	56	39
Economics	3.54	2.92	46	38
History	3.60	3.29	53	45
Field Work	4.13	4.39	24	28
Shop Work	5.65	6.44	26	25
Drawing and Drafting	5.19	7.13	32	24
Testing	5.35	6.00	20	25
Laboratory	4.97	5.13	32	30
Mathematics	3.47	3.60	53	39

Design Engineers and Sales Engineers

No. of Question	Question	Answered (Yes) Design	Answered (Yes) Sales	Answered (No) Design	Answered (No) Sales	Number of Cases Design	Number of Cases Sales
I. 2.	Constructed toy?	83%	50%	17%	50%	30	46
I. 4.	For toy itself?	0%	37%	100%	63%	19	19
I. 5.	Copied design?	12%	38%	88%	62%	17	16
I. 6.	Had sold articles?	50%	82%	50%	18%	25	45
III. 5.	Student debating?	32%	47%	68%	53%	25	45
	Dramatics?	16%	27%	84%	73%	25	45
	Student paper or book?.	36%	33%	64%	67%	25	45

I. 1. Rank of Choice of School Studies or Subjects.

	Average Rank Given Design	Average Rank Given Sales	Number of Cases Design	Number of Cases Sales
English	6.73	5.33	26	39
Economics	6.04	4.63	26	38
History	6.32	5.55	25	36
Field Work	5.54	5.13	26	38
Shop Work	5.65	5.98	26	40
Drawing and Drafting	5.31	5.95	26	39
Testing	3.73	3.95	26	40
Laboratory	3.15	3.88	26	40
Mathematics	1.81	3.85	27	40

I. *Previous Vocational Interests.*—Question 1, regarding college work, proved to be of significance in differentiating the men. Both the insurance salesmen and the sales engineers, particularly the insurance salesmen, liked English, Economics, History, and Field Work better than the design engineers did. The design engineers liked Mathematics, Laboratory, Testing, Drafting, and Shop better than the sales engineers or the insurance salesmen did.

Questions 2 and 3 showed some tendency for this differentiation, but they were not so valuable. Of the insurance salesmen, 25% of the first class and 40% of the second class had constructed toys; 50% of the sales engineers had constructed toys, while 83% of the design engineers had constructed toys. Question 4 showed a tendency of the salesmen to make things because they wanted them, while the design engineers made things because they enjoyed making them. Those who made things because they enjoyed making them, were 73% of the first class of insurance salesmen and 47% of the second class of insurance salesmen who made any things. 30% of the sales engineers who made things, and 100% of the design engineers who made things made them for the pleasure of construction. The other questions of this section were not so reliable, but they served to aid in forming a judgment or classification of the men.

II. *Choice of Other Occupations.*—In this list of occupations, there were fifteen occupations which were judged by fourteen people to be occupations that would be chosen or preferred by a man with engineering interests as primary. The other fifteen occupations were judged by the same people to be occupations that would be chosen by a salesman type of man. The occupations were carefully chosen from a much larger list; and the judgments or classifications of the occupations by each of the fourteen people were tabulated so that any occupation concerning which there was not common agreement was detected and eliminated from the list. It might be said that the occupations intended to be chosen by a sales type of person are comparatively higher-level occupations than those intended to be chosen by the

engineer type. This condition was allowed to exist, because all the men choosing these occupations are engineers and are already inclined to choose engineering type of occupations. By having them choose from a list containing very desirable sales type of occupations, there is a stronger tendency for the group to be differentiated. The Record of Interests as filled out by the salesmen and engineers contained this list of thirty occupations which were to be checked plus (+) or minus (—) according to the directions shown with them. The number of plus and minus checks made by each group for each occupation are shown in Table VIII. The same facts are shown in graphic form in Diagrams 7, 8, 9.

TABLE VIII

Choices of Occupations by Insurance Salesmen, Sales Engineers and Design Engineers

Occupation	Insurance Salesmen						Design Engineers		Sales Engineers	
	1st Class		2nd Class		Both Classes					
	+	—	+	—	+	—	+	—	+	—
Actor	24	25	24	21	48	46	5	16	6	31
Architect	28	19	24	18	52	37	19	3	29	10
Auto repairman	19	25	8	27	27	52	16	5	15	15
Auto salesman	52	8	46	3	98	11	10	6	44	1
Bank cashier	28	21	35	8	63	29	8	13	19	20
Carpenter	14	23	4	31	18	54	11	5	9	22
Captain of a ship	22	23	22	16	44	39	14	8	21	13
Chemist	17	29	16	26	33	55	15	5	25	15
Detective	23	31	20	24	43	55	6	17	7	33
Draftsman	16	36	8	27	22	63	16	7	9	25
Editor of magazine	30	16	33	10	63	26	4	17	19	17
Hardware sales	14	36	10	34	24	70	2	16	4	22
Hotel keeper	19	25	30	15	49	40	2	21	19	18
U. S. Astronomer	9	28	12	26	21	54	8	11	9	24
Lawyer	37	10	39	4	76	14	9	9	29	13
Locksmith	1	44	0	37	1	81	3	9	3	30
Locomotive engineer	20	19	11	27	31	46	17	3	23	6
Machinist	14	26	11	26	25	52	20	3	17	20
Newspaper reporter	38	8	37	6	75	14	5	14	25	9
Pattern-maker	5	39	2	25	7	64	10	6	7	23
Policeman	1	50	0	48	1	98	0	27	0	43
Private secretary	38	9	22	17	60	26	3	20	14	13
Purchasing agent	46	8	41	3	87	11	9	8	41	2
Real estate agent	42	8	47	3	89	11	6	16	29	7
Research worker in physics	12	27	14	21	26	48	20	3	22	13
Sculptor	14	31	9	21	23	52	5	15	3	22
Statistician	13	32	18	17	31	49	7	18	12	25
Stockbroker	35	8	35	7	70	15	7	8	32	5
Toolmaker	3	31	4	30	7	61	13	8	3	25
Watchmaker	2	39	0	35	2	74	5	11	0	33

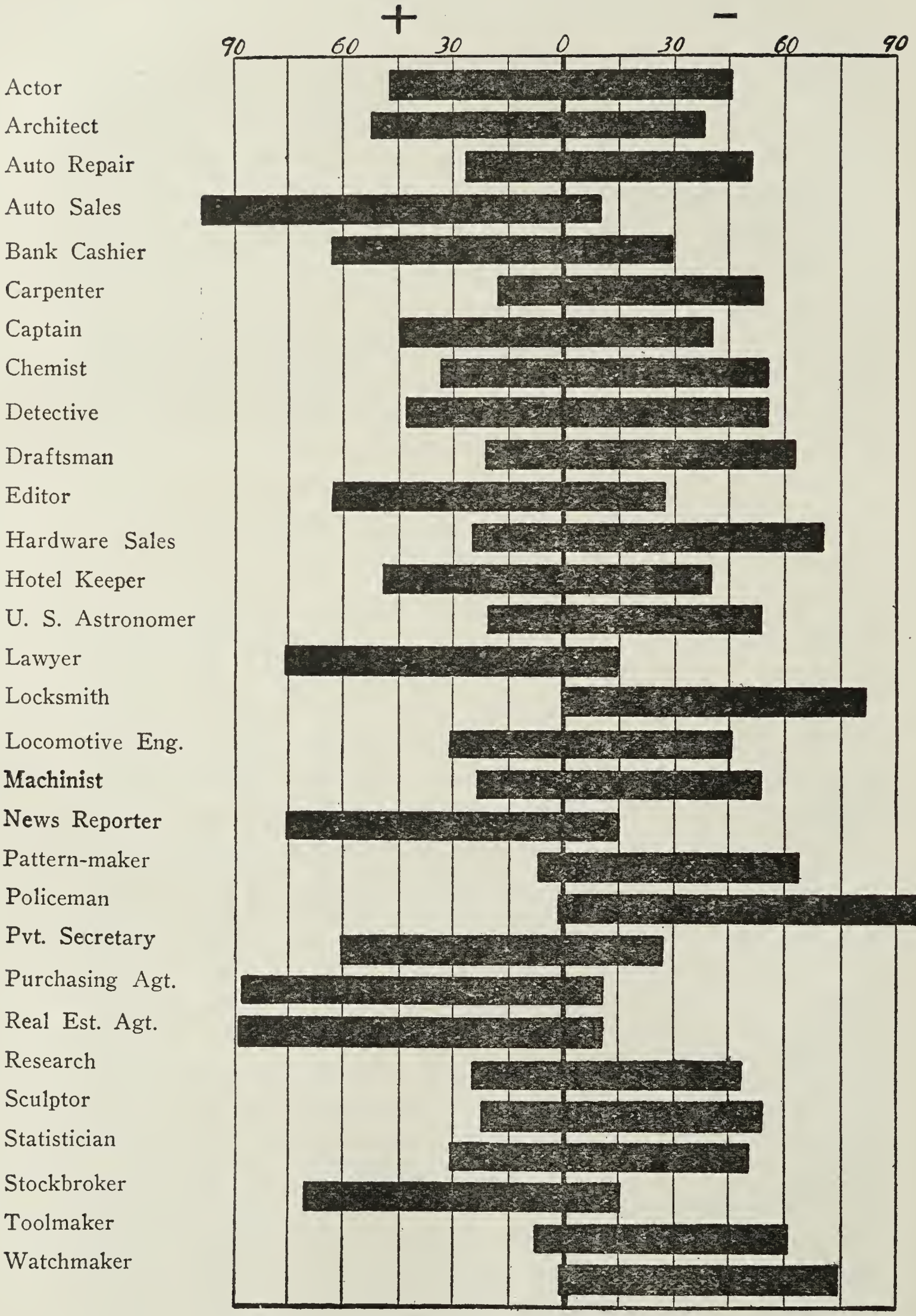

Diagram 7. Number of Choices Showing Preferences for (+), or Rejection of (—) Occupations by Insurance Salesmen. Number of men represented, 124.

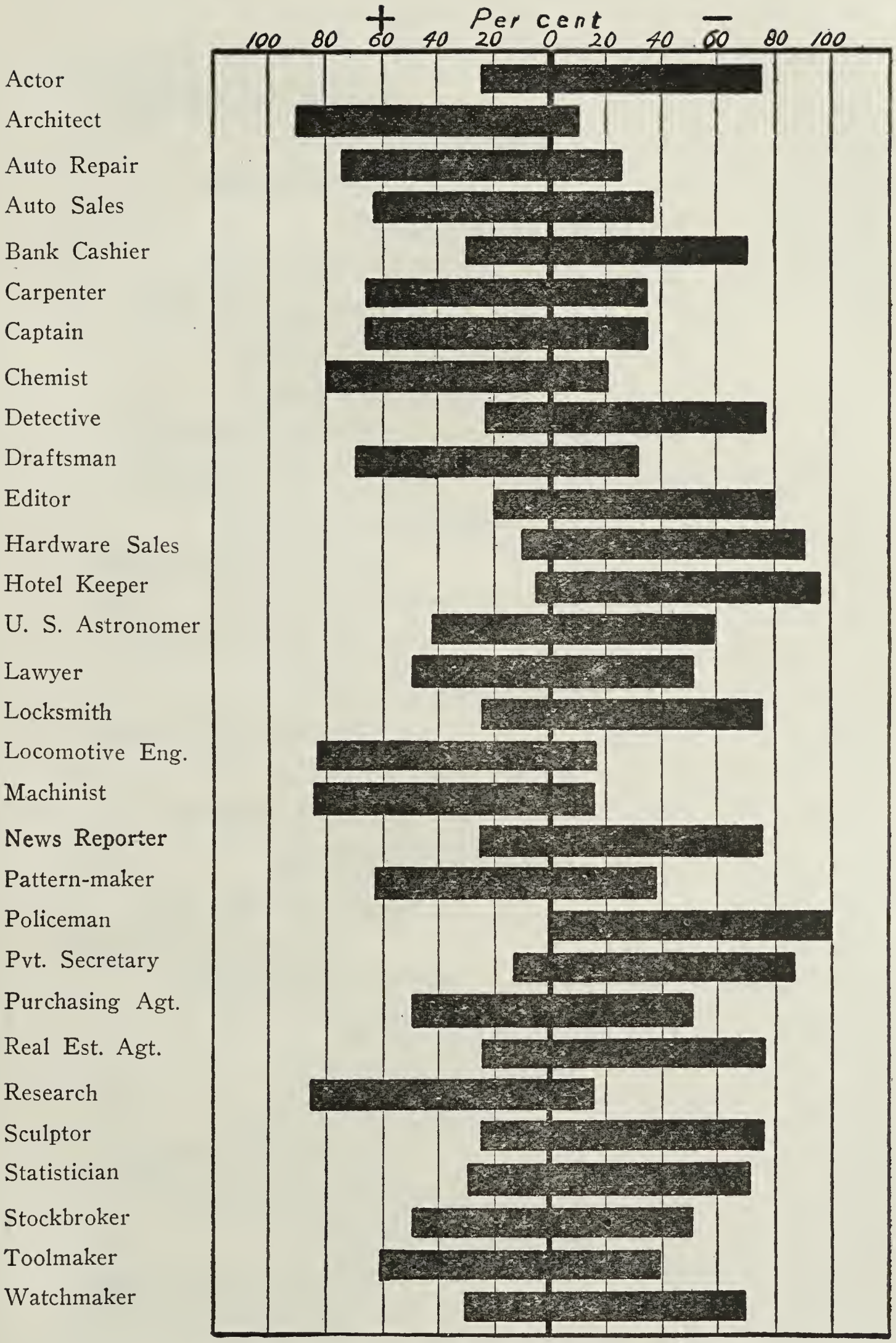

Diagram 8. Percentages of Choices Showing Preference for (+), or Rejection of (—) Occupations by Design Engineers. Number of men represented, 28.

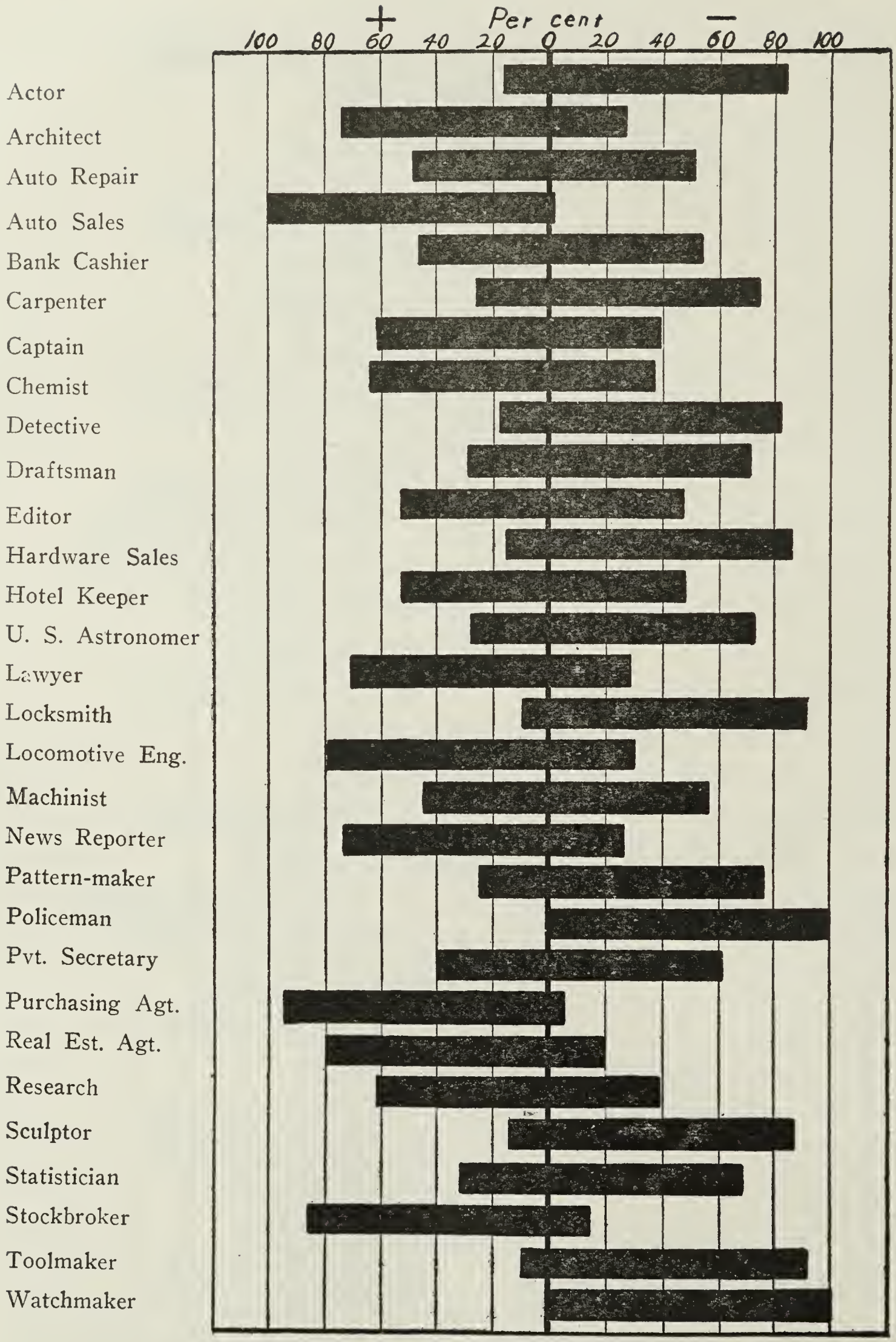

Diagram 9. Percentages of Choices Showing Preference for (+), or Rejection of (—) Occupations by Sales Engineers. Number of men represented, 50.

From the list of thirty occupations, twenty occupations were later chosen, because they had given the best results for differentiating; and a new form was prepared as reproduced on page 36. The student engineers are directed to check ten of them with a plus (+) as the more desirable, and to check ten with a minus (—) as the less desirable. The twenty occupations classified as those chosen by an engineering type of man and those chosen by a sales type of man are as follows:

Occupations Chosen by Engineering Type	Occupations Chosen by Salesman Type
Architect	Automobile salesman
Automobile repairman	Bank cashier
Carpenter	Editor of popular magazine
Draftsman	Hotel keeper or owner
U. S. Government astronomer	Lawyer
Machinist	Newspaper reporter
Pattern-maker	Private secretary
Research worker in physics	Purchasing agent
Toolmaker	Real estate agent
Watchmaker	Stockbroker

The relative percentage of the sales or engineering type of occupation chosen by a man indicates whether he is a sales type or an engineering type of man. The scoring method explained more fully is as follows: A stencil in the form of a cardboard with perforations or slots allowing only the engineering type of occupations to be visible is placed over the list of occupations which have been checked. The number of plus marks is counted and recorded in the margin. The number of minus marks is also recorded. Then this stencil is removed and another stencil is placed over the list, allowing only the sales type of occupation to be visible; and then the number of plus and minus marks is recorded. The number of *plus* marks before engineering occupations is added to the number of *minus* marks before sales occupations in order to get the number of checks in favor of engineering occupations. The number of *minus* marks before engineering occupations is added to the number of *plus* marks before sales type of occupations to get the number of checks in favor of sales occupations. Finally the number of marks in favor of sales occupations is divided by the total number of check marks to get the percentage of marks in favor of sales occupations.

It would not be necessary to count both the plus and minus marks if all the subjects checked all the occupations; but this method of scoring can be used even though not all the occupations are checked.

The *Record of Interests* papers of the salesmen and engineers were scored according to the above method; and the results with only the twenty selected occupations being considered are presented here. Diagram 10 shows the percentages of sales occupa-

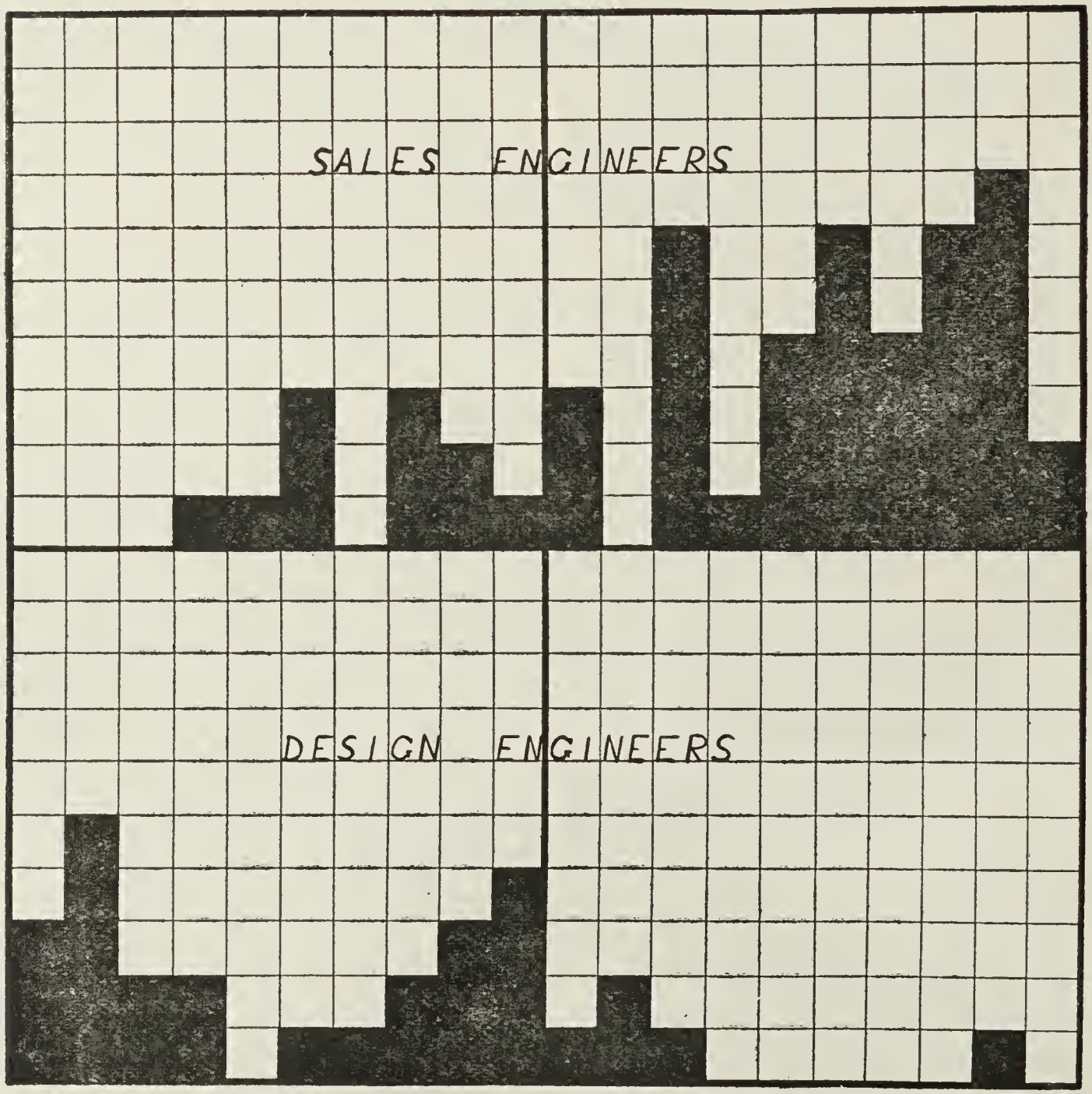

Diagram 10. Percentages of Choices Showing Preference for Occupations requiring Sales Type of Person.

Considering the diagram as a four-fold table, the interest test (Record of Interests) places correctly eighty-two per cent of the engineers. $r_U = .84$.

tions chosen by each group. The percentages of sales occupations chosen are shown along the base line or x-axis. The height of the columns represents the number of men choosing the particular percentages of sales occupations. For the insurance salesmen the percentages of sales occupations chosen were 73 per cent for the first class and 80.6 per cent for the second class. For the sales engineers the preference for sales occupations was 67.7 per cent. For the design engineers the preference for sales occupations was only 30.0 per cent.

This section, "Choice of Other Occupations," is one of the most reliable sections of the *Record of Interests;* and no subject ever failed to fill it out. The men take an interest in choosing the occupations and expressing their preference. The engineers and the salesmen showed a definite tendency to like or be interested in occupations which in nature of work were similar to those they were already following. The kind of occupations which they thought would give them the greatest satisfaction to follow was a significant criterion of the kind of work in which they could be and were already successful.

By computing for each engineer the percentage which his choices of occupations of a sales nature bore to his total number of choices, a definite measure of his sales engineering interests as opposed to design engineering interest was obtained. I assumed that if more than fifty per cent of a man's choices were occupations requiring a sales type of person for success in them, that man was a sales type of person; and if more than fifty per sent of the man's choices were occupations requiring a design engineering type of person, that man was a design engineering type of person. By this measure, 78 per cent of the sales engineers were of a sales type; and 82 per cent of the design engineers were of an engineering type. Or assuming that we did not know the actual occupations of the engineers, those engineers which this test of interests alone would select for sales engineering, would be 89 per cent correctly placed or classified; and the men which this test of interest selected for design engineering would be 68 per cent correctly placed or classified.

III. *Avocational Interests.*—Questions 1, 2, 3, and 4 did not

show any special differentiation except as they showed that the sales type of man was more interested in the social sports while the engineering type often enjoyed photography or some professional or technical hobby. Question 5 showed that there was a definite tendency for the sales type of man to take more active part in extra academic activities, (See Table VII). 51 per cent of the insurance salesmen of the first class, and 56 per cent of the second class, 47 per cent of the sales engineers, and 32 per cent of the design engineers had taken part in student debating. 45 per cent of the first class and 48 per cent of the second class of insurance salesmen, 27 per cent of the sales engineers, and 16 per cent of the design engineers had taken part in dramatics. 40 per cent of the first class and 52 per cent of the second class of insurance salesmen, 33 per cent of the sales engineers and 36 per cent of the design engineers had taken part on a student paper or annual book.

IV. *Social Interests.*—The answer to the questions on social interests were not significant in their nature in differentiating the men, except as they were a definite means of showing whether or not the man has social interests and is congenial. In answer to question 5, 60 per cent of the first class and 67 per cent of the second class of insurance salesmen, 77 per cent of the sales engineers, and 77 per cent of the design engineers preferred a roommate. The other results of this section as a whole were consistent with the facts of differentiation shown in the other sections.

V. *Interests of Relatives.*—The interests of the relatives as shown by their occupations indicated a nature definitely similar to the choice made by the man considered, but there were exceptions, so that the choice of occupations made by relatives could not be used as a criterion of the proper choice for the man, except as it might be consistent with and strengthen the judgment of a man's interests as based upon the other facts of the total *Record of Interests.*

VI. *Technical Interests in the Westinghouse Organization and Its Opportunities.*—Here the man is asked for a definite statement of his particular interests in the Westinghouse Com-

pany. The results obtained in this section agree almost perfectly with the choice of kind of occupation indicated in the other sections.

IX. Application of Psychological Tests to the Problem

1. *The Nature of Mental Ability and Its Problems for Tests*

By psychological tests, we mean those tests which are consciously based upon psychological principles and are for measuring a certain mental process or processes. Often such a test is intended to measure general intelligence. By general intelligence is meant not general information, but what is synonymously called menal alertness, mental capacity, or innate mental ability. In general, psychologists accept the theory that general intelligence is composed of a group of mental abilities or factors. Practically the same conception is held by the laymen; for when a layman judges or makes an estimate of another person's general intelligence, he considers that person's particular capacities and abilities all together, and approximates a sort of average of them which is compared with the averages of other people's capacities and abilities. However, it is recognized that, except in the sense of a very broad general intelligence, people are individually different in that the general intelligence of one is composed of particular capacities and abilities different in degrees of perfection from those in the group of particular abilities composing another person's general intelligence. That is, it may be said that there are different kinds of intelligences. These different kinds of intelligences are largely due to particular interests directing the whole general intelligence in certain directions; but on the other hand, the interests are given substantial basis by particular abilities which make activity in a particular line easy and interesting. In this way, what is practically considered as a kind of intelligence directed by particular interests, is a group of special abilities developed and integrated so as to be of practical use in the life of the individual. If general intelligence or any kind of intelligence is analyzed very minutely, it is found

to consist of very particular abilities, which are neural bonds between a particular situation and a particular response. Certain ones of these are essential for certain special abilities. If these essential very particular abilities are not present, the individual is not considered as specially qualified for the particular work. Other abilities or all of them together as general intelligence, may function vicariously in accomplishing to a lesser degree what is done by a special ability; but ability in that particular kind of work is limited by the weakness or lack of the ability peculiarly essential for marked success in it. It is the differences between individuals in the degree to which they possess these special abilities that differentiates them for particular lines of work. Such a special ability integrated and functioning with other abilities is a kind of intelligence, which, if tested, would yield a measure of potentiality for success in a particular kind of occupations or kind of work. Such a test may be a special ability test or it may be a trade test.

Success in some kinds of work may require not a special ability but a certain amount of general intelligence, which is considered as a certain potentiality in all of the large group of abilities usually functioning in the many activities carried on to a more or less extent by all persons. For an occupation in which greater general intelligence means so much greater capacity for success, persons could be differentiated by a general intelligence test. Such a test measures the abilities composing and therefore correlating with the average of the group of abilities called general intelligence.

These hypotheses are explained here as being the most pertinent to the problem being studied. They are stated in the form of hypotheses, not as a solution to the problem, but as a restatement of the psychological questions raised before in the Introduction. The method for attempting to answer the psychological questions, was to work in accordance with these hypotheses. First, a general intelligence test was given to ninety-four graduate student engineers. Later, a test was devised which was intended to test special ability for particular kinds of work.

2. *The Results of a General Intelligence Test*

The general intelligence test used was the Personnel Bureau Test VI., which is a modified form of the Army Alpha general intelligence test. This test was given to ninety-four graduate engineers who were students in the Educational Department of the Westinghouse Electric and Manufacturing Company. Most of these men had been in the Educational Department from six months to a year. The men were already classified according to the kind of work to which they were to be assigned. The average of the test scores for each group is shown in Table IX.

TABLE IX.

Averages of General Intelligence Test Scores for Each Group of Graduate Student Engineers.

Group	Mean Score	Median Score	Estimated Rank in Intelligence, Committee's rating
Design engineers	154	150	12.95
Operating, Service, Works	140	144	84.2
General engineers	137	135	59.9
Sales engineers	129	130	56.5

The test scores for each group of engineers are shown graphically in Diagram 11, in which the height of each column indicates the number of men making any particular score shown on the horizontal axis. Although it has not been the intention to select the men with greater mental ability for any particular line of work, the results of the test indicate that there has been a tendency to select the men with greater mental ability for engineering, particularly design engineering. This agrees with the results of the study of the technical school grades. However, the difference is not sufficient to differentiate the men, except that a critical score might be established, below which a man could not be accepted for design engineering. The correlations between this test and other tests and ratings are shown in Table X.

On examining the cases in which the test scores do not agree with estimated intelligence, we find that there seem to be certain tendencies causing the disagreement. A table of the cases in which there is the greatest disagreement, and those in which there

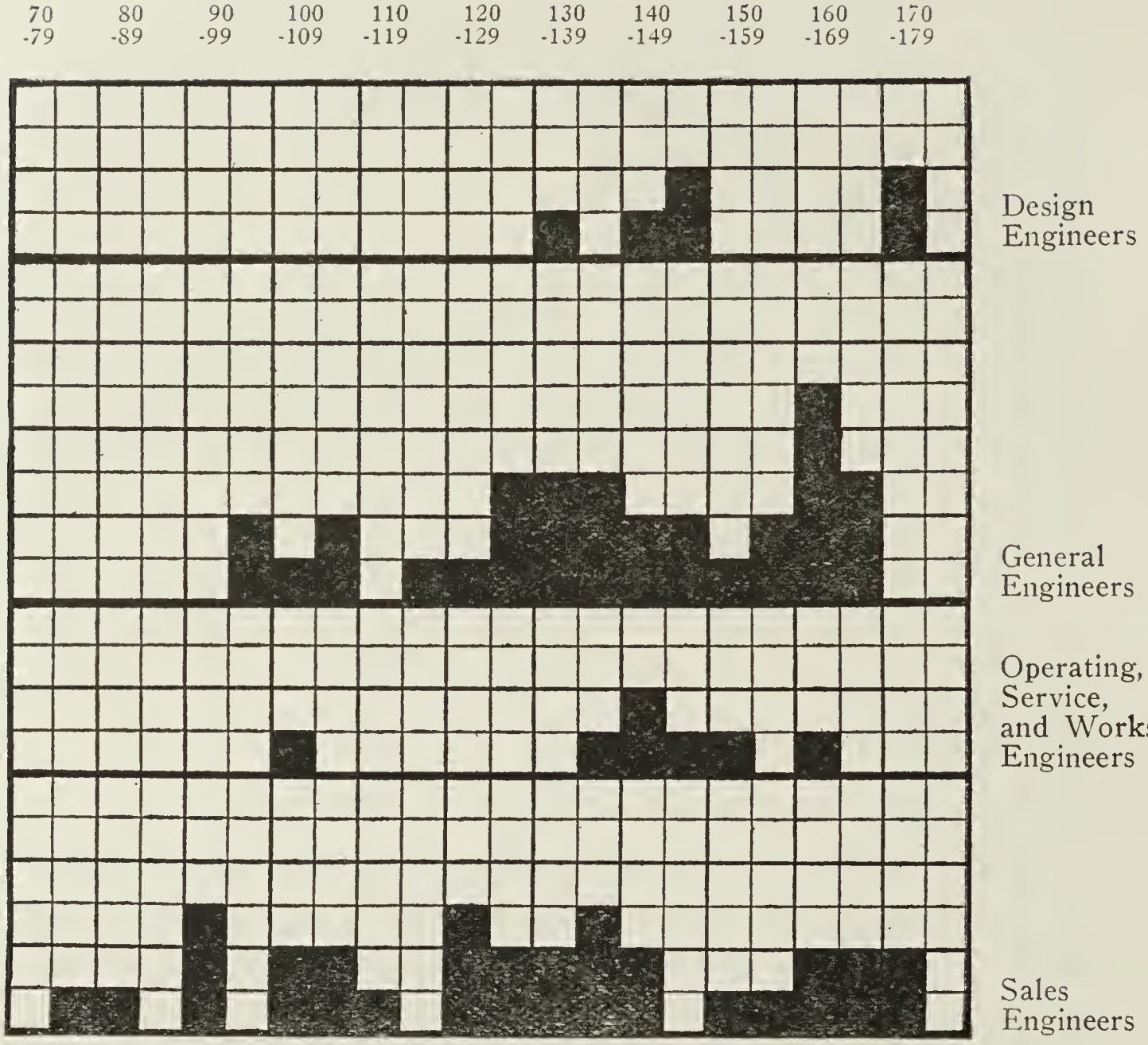

Diagram 11. Scores in Bureau Test VI of Graduate Engineers Classified by Occupations.

TABLE X.

Correlations of Bureau Test VI Scores with Other Criteria.

Criteria Correlated with Test VI.	Number of Cases	Correlation (r)
Estimated intelligence, committee's rating	74	+.46
Composite of technical school grades	56	+.37
Technical school grades in languages	43	.0
Technical school grades in mathematics	34	+.34
Technical school grades in shop	24	+.67
Technical school grades in engineering	53	+.26
Technical school grades in academic subjects	35	.0
Company shop ratings	58	.0
Ratings at employment interview	18	+.58
Rating in intelligence at employment interview	18	+.57
Bureau Test 10, Part I (Insurance salesmen Class 1)	64	+.64
Bureau Test 10, Part I (Insurance salesmen Class 2)	58	+.91
Bureau Test 10, Part I (Engineers)	18	+.69
Bureau Test 10, Part II (Engineers)	18	+.38

is the greatest agreement is presented for study and comparison of those cases. See Table XI.

TABLE XI.

Cases in Which Test Scores Do Not Correlate with Estimated Intelligence and Cases in Which the Correlation Is High.

Number of Case	Rank by Test	Estimated Intelligence Rank	Assignment
Disagreement: High Rank by Test; Low Rank by Committee			
1	5½	61	Engineering
2	12	57	Sales
3	18	63	Engineering
4	21	62	Operating
5	12	49	Engineering
6	10	39	Sales
Disagreement: Low Rank by Test; High Rank by Committee			
7	56½	13	Sales
8	52	16	Sales
9	52	17	Sales
10	61	26	Engineering
Agreement: Both below Average			
11	65	66	Sales
12	63	64	Sales
13	48	48	Sales
Agreement: Both above Average			
14	1	1½	Engineering, Design
15	2	5	Engineering, Design
16	8½	6	Engineering
17	8½	9	Engineering
18	12	12	Engineering
19	24	25	Engineering

In the group of those who received a high rank by the test, but a low rank by the committee, it is seen that most of the men in this group are engineers as contrasted with salesmen. These men tend to be more of the profound intellectual type as contrasted with the bright attractive type. For this reason their pure reasoning or intellectual ability tends to be underestimated. It is also interesting to note that in the case of greatest disagreement, that of No. 1, the engineer was rated on the rating scale at time of employment, and he received in physical qualities only 12 points out of a possible 20, in personal qualities only 12 points out of a possible 20, but in intelligence he received 20 points, the highest possible rating.

Of the graduate engineers who received a low rank by the test but a high rank by the committee, three are assigned as salesmen, and but one as an engineer. It is seen that there is a tendency for the man with high intelligence but comparative lack of highly-rated appearance and personal qualities to be under-estimated; but the man with good or pleasing appearance and personal qualities is over-estimated in intelligence. This is the usual tendency often found, because we tend to consider other qualities which are evident, but which, although valuable traits, are not intelligence as measured by the test. Of those cases in which there was perfect or most nearly perfect agreement, all those ranking above average were engineers, and all those ranking below average were assigned to sales work. It seemed very probable that in selecting men for engineering, particularly design engineering, intelligence had been the chief qualification considered; but in choosing men for sales engineering, other qualifications had been given much weight.

3. *Construction and Evaluation of a Special Test for Differentiating Graduate Student Engineers*

(a) *Hypothesis of the Test.*—As was stated in Section II, the problem of this research was to discover or devise a method and means for selecting from the whole group of graduate student engineers those who would give their services most efficiently as sales engineers. The general intelligence test did not adequately separate the sales engineers from the other engineers. Evidently the difference between sales engineers and other engineers is a qualitative one more than it is a quantitative one in intelligence. Moreover, the difference is a relative one; for the purpose is not so much to pick a certain standard of sales engineers as it is to pick a certain number, about half of the group, who will be the **best selection from that group** for developing into sales engineers. For measuring this qualitative difference a general intelligence test could not be used. Moreover, any general intelligence test available was too easy for this group of men, because they all made high scores and were not sufficiently differentiated by it. Finally, the content or subject-matter of existing intelli-

gence tests was not relevant to the engineering profession, and therefore did not interest or appeal to engineers as a test might be made to do. For these reasons, another test was devised to distinguish two different kinds of intelligence.

The theory upon which the test was constructed is that, of this group, the sales engineers on the one hand, and the design engineers on the other hand, are relatively at opposite extremes in the kind of intelligence possessed. The sales engineer as a result of his innate particular abilities, his environment, and his training, has interests and abilities that make for an intelligence better fitted for the work of a sales engineer. He has developed habits of thinking and attitudes toward other people which are more like those of a salesman; and his interests and apperceptions have led him to pick up and retain more of the information, particularly of a business, social, and human interest nature, which enables him to fit into the work of a sales engineer better than the design engineer type would.

The design engineer type has innate abilities and interests which with environmental influences, experiences, and training, have developed into an intelligence better fitted for the work of a design engineer. He worked intensively at his technical problems in college, and has developed habits of thinking and attitudes which are more compatible with the work of a design engineer. It was with these subtle differences between the sales engineers and design engineers in mind, that the test was devised.

(b) *Directions for the Test.*—The nature of the test, being composed partly of questions of a technical nature as well as of general information, makes it inadvisable to publish it. However, we publish here the directions just as they are given with the test. The directions include samples which indicate the nature of the various kinds of problems in the test. These samples are to explain the test so that the subject will understand clearly what he is to do with each kind of problem; therefore, they are simple and easier than the problems and questions in the actual test. Nevertheless, they sufficiently indicate the nature of this test for the purposes of this report.

TEST 10

Test for Graduate Student Engineers

Prepared by B. V. Moore, Research Fellow, Expressly for the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pennsylvania.

Part I

To the Westinghouse Student Engineer:

This is a test to help you place yourself in the Westinghouse Company where you can be most successful. The results of the test will be held strictly confidential. You are asked to do your best with the test so that the Company will be in a position to give you the greatest possible opportunity. After the test has been scored, you may receive your score individually; and you may discuss the results confidentially with the executives of the Educational Department.

Fill in the blanks as indicated.

Name .....
Place of Birth .....
If not born in U. S., how many years have you been in U. S.?.....
Kind of Engineering for which you are trained.....
(Eletrical, Mechanical, etc.)
Date .....

Now read the Directions on the next two pages very carefully, but do not turn to page 4 until told to do so.

DIRECTIONS

Inside this booklet you will find a lot of things to do. Samples of all the different kinds of things to be done are given below with directions for doing each one. **Follow the directions carefully, and pay close attention to the examples so that you learn to do each thing correctly.**

(a) People hear with the **eyes ears nose mouth**

In such sentences, one of the last four words will make the sentence a true statement of fact. Underline the right word, thus:
People hear with the **eyes** **ears** **nose** **mouth**

Another example of the same thing correctly marked, is:
France is in **Europe** **Asia** **Africa** **Australia**

(b) locomotive—train :: horse— **hub buggy car baggage**

The first word, "locomotive" is related to the second word, "train," in the same way as the third word, "horse," is related to **one** of the words following it. You are to underline that word which is related to the third word in the same way as the first two words are related to each other. In this example, "locomotive" is related to "train" as "horse" is related to "buggy"; for a locomotive pulls a train, and a horse pulls a buggy. Therefore, **"buggy"** should be underlined, thus:
locomotive—train :: horse— **hub** **buggy** **car** **baggage**

Another example of the same thing correctly marked, is:
woman—beautiful :: man— **girl old mother handsome**

Handsome is underlined because a man is described as handsome in the same way as a woman is described as beautiful.

(c) The concert was **(delicious lovely delightful)**

In such sentences, only one of the words or phrases in parenthesis can be used correctly. You are to underline the correct word, thus:

The concert was **(delicious lovely <u>delightful)</u>**

Another example of the same thing correctly marked, is:

He **(isn't <u>doesn't</u> don't)** do that kind of work.

(d) little same as **large child big small**

In this kind of problem, there is always just **one** word in the group of four words which has the **same** meaning as the single word given first. In this example, "little" has the same meaning as **"small."** Therefore, **"small"** should be underlined, thus:

little same as **large child big <u>small</u>**

Another example of the same thing correctly marked, is:

talk same as **story truth <u>speak</u> hear**

(e) soft opposite of **brittle hard yielding rough**

In this kind of problem, there is always just one word in the group of four words which has exactly the **opposite** meaning of the word given first. In this example, "soft" has the opposite meaning of **"hard."** Therefore, **"hard"** should be underlined, thus:

soft opposite of **brittle <u>hard</u> yielding rough**

Another example of the same thing correctly marked, is:

encourage opposite of **courage inconvenience <u>discourage</u> inspire**

(f) Don't put all your eggs in one basket.
....The mouse that has only one hole is soon caught.
....Catch the bear before you sell his skin.
....The proof of the pudding is in the eating.

In such groups of statements, there is always just one which gives essentially the same meaning as the first one. Put a cross before the statement which means the same as the first statement, thus:

Don't put all your eggs in one basket.
.X.The mouse that has only one hole is soon caught.
....Catch the bear before you sell his skin.
....The proof of the pudding is in the eating.

Another example of the same thing correctly marked, is:

Long absent, soon forgotten.
....Absence makes the heart grow fonder.
....Distance lends enchantment to the view.
.X.Far from eyes, far from heart.

When the signal is given, you are to turn to page 4 and do these things as you have learned to do them here. Do not ask questions. If you forget how to do any of them, you may turn back to these pages, but to do so unnecessarily will waste your time.

Work rapidly. You will be allowed twenty minutes. You may not be able to get through in that time; but do as much as possible.

Mark every question. If you are not sure about your answer to something, guess at it, and go on to the next question. There are no catch questions.

When the signal is given, begin at the top of the next page, and work through the remainder of the booklet, without skipping about.

Do not turn over to the next page until you are told to do so.

Part II

On the following pages are some more things for you to do. Samples of the three different kinds of things to be done are given below with directions for doing each one. **Follow the directions carefully, and pay close attention to the examples so that you learn how to do each thing correctly.**

(a) **silver copper glass aluminum gold**

In such groups of five words, there are four words which represent things or ideas that can be thought of as similar in a certain way. That is, they can be classed under the same fundamental idea or conception. One of the five words represents something that is not like the other four words in the way that they are all like each other; and therefore, it cannot be classed with them under the same conception or category. You are to discover the fundamental idea of the classification, and underline the word that is not included. In the example above, all the materials are conductors of electricity, except **"glass,"** which is relatively a non-conductor. Therefore **"glass"** should be underlined, thus:

silver copper <u>glass</u> aluminum gold

Another example of the same thing correctly marked, is:

shunt motor <u>transformer</u> telegraph sounder

synchronous alternater exciter electroplating apparatus

<u>Transformer</u> is underlined because it has to do with **alternating** current, but the other four words have to do with direct current.

(b) Other factors remaining constant, the electric current in a wire varies inversely as the resistance of the wire.

True False

You are to decide whether such statements are true or false, and then underline the appropriate word, **True** or **False,** which indicates the nature of the statement. The above statement is **true;** therefore, **"True"** should be underlined, thus:

Other factors remaining constant, the electric current in a wire varies inversely as the resistance of the wire.

<u>True</u> False

Another example of the same thing correctly marked, is:

Laminated armature cores are used, because they retain magnetism better.

True <u>False</u>

(c) What direct current at 110 volts will give the same horsepower as a direct current of 5 amperes at 220 volts?

Answer.....amperes

Such problems are to be solved. You may use the margin of the pages for figuring. Write the answer in the place indicated, thus:

What direct current at 110 volts will give the same horsepower as a direct current of 5 amperes at 220 volts?

Answer....10....amperes

Another example correctly solved, is:

A direct current motor uses a current of 7.46 amperes at 250 volts. A Pony brake test shows that the motor is giving 2 horsepower. What is the efficiency of the motor?

Answer....80%....

When the signal is given, you are to turn to the next page and do these things as you have learned to do them here. Do not ask questions. If you forget how to do any of them, you may turn back to these pages, but to do so unnecessarily will waste your time.

Work rapidly. You will be allowed thirty minutes. You may not be able to get through in that time, but do as much as possible.

Mark every question. If you are not sure about your answer to something, guess at it, and go on to the next thing. There are no catch questions.

When the signal is given, begin at the top of the next page, and work through the remainder of the booklet, without skipping about.

Do not turn over the page until you are told to do so.

(c) *Construction of the Test.*—A test is developed and improved much as a new machine is developed. It is brought nearer perfection, and the final efficiency attained by eliminating one difficulty after another and by taking advantage of one possibility for improvement after another, just as the dynamo was brought nearer perfection from a cast iron bipolar series-wound machine to the present efficient machine with laminated cores, commutating poles, commutating pole-face windings, compound wound field, balance coils, etc. This test was developed in much the same way. It may be found later that some of the reasons for making the test as it is, have no basis of fact; but the intention was not to fail to take advantage of any possible means or device for differentiating between the sales engineer and the design engineer type. Therefore, some of the features of the test may seem trivial and even arbitrary; but they were not discarded, because there was no proof of their futility.

To discuss the test more in detail, we shall begin with the information questions of Part I. (See Directions, a). Of the one hundred sixty questions in Part I, forty, or one-fourth, are questions of information. It is believed that the sales type of engineer has been interested in other things in addition to his books and strictly technical training. He not only has been a good mixer in college and has taken part in extra-academic activities, but he also has been interested in the affairs of the social, economic, business, and work-a-day world. The potential salesman's abilities, and with them his interests, have tended to select and retain for him those items of information which are peculiar to a sales type of person and make him such a person. A definite method was

followed in order to have the questions such that a sales type of person would answer best. After studying the occupational descriptions of the various lines entered by sales engineers, a definite prospective customer in a particular industry was imagined. Supposing that I was sales manager, I outlined the kind of experiences and information I should want my salesman going to that customer to have. After doing this for each class of customer for each sales department, I prepared a composite list of kinds of information and experience which I should expect a successful sales type of engineer to have accumulated in his early life, his high school and college life, his social and fraternal life, his business life, his sports, amusements, and avocations, and his reading. With this list before me, I selected from other tests and formulated new questions which would cover these twenty or more different classes of information and interests.

The second type of problem chosen was the analogies test. (See Directions, b). Forty items of this type were included. In studying the general intelligence test papers, Bureau Test VI, the scores of the sales engineers in the different kinds of tests making up the total test were compared with the scores in those tests of the other engineers making the same total score. It was found that with the small number considered, twenty-five sales engineers and sixteen others, the sales engineers did better in the analogies test, although their total score on the whole examination was the same as the other engineers' with whom they were compared.

The next three tests might be considered or classified as vocabulary tests, but they are intended to be also more than that. Recognizing the fact that the salesman must be able to express his ideas and understand what others are trying to say, an attempt is made to measure not merely his knowledge of words, but also his sense of their finer meanings and implications in certain usages. The correct answer to a particular test item of this sort often cannot be made according to any dictionary definition or any rule of rhetoric. It depends upon usage and a fine

sense of propriety. To answer them correctly the man cannot stop to reason out the answer, or he will be lost; but he must respond as he feels about the proper sense of the word. It is an attempt to measure the ability not of using words but of comprehending the meaning of other people's statements and of getting other people to undertsand us as we expect them to understand us.

The proverbs are intended to measure somewhat the same thing as the preceding types of tests measure, namely ability to read and understand sentences. In addition, it is considered as a test of the ability to generalize or think consistently. It measures the ability to interpret the gist of a complete statement rather than the meaning of words or phrases. In the proverbs test, several possible forms were considered. I thought at first that Professor L. L. Thurstone's form, a prototype with four other sentences, would be used; but this was abandoned as too long for one item. Then I thought that it would be possible to score Professor Thurstone's form as two items, one point for each sentence or phrase checked correctly. But considering the probabilities involved, this plan was dropped. By that plan, a subject in selecting the first of the two sentences to be checked, has a two-out-of-four or fifty-fifty chance. If he is a capable subject he gets the first one right. Then in checking the second one he has a chance of only one out of three; and thus the problem is made more difficult. However, if he were a much less capable subject, the first one he checks might very possibly be a wrong one; but he has two chances out of three of selecting the right one in checking a right sentence as the second one. Thus the problem is made more difficult for the more capable and less difficult for the less capable; and there is a tendency to eliminate a showing of differentiation in capacity. For these reasons, the proverbs were constructed so that there would be just one probability, namely one out of three chances.

Part II. is apparently a test of technical engineering ability. However, it is not to be considered a trade test. It would be such if it were given to a group of men, some of whom were

engineers and some of whom were not, but the test is for engineers only, and is not to distinguish engineers from people that are not engineers. The technical information required to pass the test is comparatively easy for electrical engineers; for the test was designed to require only such information and engineering ability as every graduate of all standard schools would have. When the test is given to a group of engineers, it is essentially an intelligence test; but it tests a certain kind of intelligence. The hypothesis upon which it is based is that the man who is more capable as an engineer, who has his interests in the profession, and who has held himself more intensively to his books, shop, drafting board, and mathematics, is the design engineer type, and is the kind of engineer who will tend to pass this kind of test better than he would pass Part I. It is expected that a pure design engineer type of man will pass such an intelligence test better if the vocabulary and content is that with which he is accustomed to work and think about.

The first kind of problem or question in Part II, (a), is, as the Directions explain, a test of ability to deal with fundamental conceptions found in mechanics, physics, or engineering. The test is intended to measure the subject's alertness in dealing with or in juggling such technical ideas. It is even hoped to be a test of association or originality in seeing the relations involved in such fundamental conceptions. It calls for analysis and generalization in the technical field.

The second type of question, Part II, Directions (b), is composed largely of questions calling for technical information; but the questions are so stated that the subject must read them carefully and think straight to give the right answer; for they cannot be answered directly from general principles or textbook information, but require the application of general principles.

The third type of problem, Part II, Directions, (c), is manifestly a straight mathematical engineering problem. The problems are not highly technical, but require straight thinking and accurate computation. Problems in mensuration, mechanics, and general physics are included as well as problems in electrical engineering.

In a psychological test with a time limit, it seems most logical to have the steps or items to be solved, of equal difficulty, particularly if speed is considered as a measurable factor of the ability to be tested. Therefore, if the items cannot be made of equal difficulty, it does not seem consistent to arrange the items in the order of their difficulty, putting the most difficult to be solved last. This tends to minimize the differentiating process rather than make the most of it. The capable subject gets through the easier items first, but is held back by the more difficult material ahead, while the less capable subject coming through the easier material then tends to catch up with the capable man. Moreover, the difficult material which the capable person might be able to solve, but which the less capable man never could solve, is never reached by either. It might be argued that the more difficult material be placed first and the easier later, so that the less capable subjects would have to pass it over after spending a little time on it. The capable man would get credit for it and also for much more easier material, which would make his score much larger than that received by the less capable man. Thus the differentiation would be greater. For these reasons, no especial effort was made to rank the problems, particularly in Part II, in order of difficulty; but some attempt was made to keep the difficulty fairly constant. Of course the first few items were made easier so that all subjects could get the correct idea and get fairly started.

(d) *Standardization of the Test.*—In the process of developing and testing the test, Part I. was given first to the members of the seminar of the Bureau of Personnel Research, composed of two persons with the degree of Doctor of Philosophy in psychology, and six graduate students. The number of the item which was reached by each subject at the end of twenty minutes, was checked, and the subjects asked to complete all the items of the test. Also, the subjects in the seminar were asked to criticize and put a question mark after each item that was ambiguous or of questionable reliability. Then both the errors and the criticisms were tabulated for each of the one hundred sixty items. After making a few minor changes in Part I. as a result of this first

trial, it was given to a class in the School of Insurance Salesmanship. Sixty-one men and three women, about half of whom were college people, were in this group taking the test. Part I. was then revised a second time and given to fifty-five men and five women in another class in the School of Insurance Salesmanship.

The process of constructing and standardizing Part II. was somewhat different. The True-False questions were taken from Professor E. L. Thorndike's engineering test. The problems were taken partly from Professor L. L. Thurstone's engineering tests, partly from standard engineering textbooks, and part were originally devised by myself. The disparate word test items, that is, the groups of words with one word not included in the fundamental conception, were all originally devised by myself.

For standardizing Part II., it was studied and the problems worked by two engineers of the Westinghouse Electric and Manufacturing Company. Then the problems were worked, and the whole of Part II. carefully criticized by Professor W. R. Work of the Department of Electrical Engineering, Carnegie Institute of Technology. Then both Part I. and Part II. were given to three seniors in electrical engineering just graduating from the Carnegie Institute of Technology. After a third revision, the entire test, Part I. and Part II., was given to twenty-eight design engineers and two general engineers in the Westinghouse Electric and Manufacturing Company. Later the entire test was given to fifty-nine sales engineers in the same company.

The specifications for selecting the Westinghouse engineers for the test were: (1) They all should be graduates of technical schools. (2) They should have been out of school and in actual work with the Company not more than five years and not less than one year. (3) The design engineers should be beyond doubt of the type desired in design engineering. They should have proven successful and should be satisfied in their work. There should be no doubt that they were properly placed. (4) The sales engineers should be beyond doubt of the type desired in the sales department. They should have proven successful

and should be satisfied in their work. There should be no doubt that they were properly placed as sales engineers.

With these specifications, the heads of the engineering departments selected the design engineers; and the whole list was gone over carefully by the Chief Engineer. The sales engineers were selected in a similar way by the sales managers. A few of the sales engineers had been out of school more than five years; but it is believed that the two groups were composed of as pure type representatives of the two kinds of engineers as could be obtained. In addition to helping make the selection, the Chief Engineer rated the design engineers on their ability as design engineers; and the sales managers rated the sales engineers on their ability as sales engineers.

(e) *Results of the "Test for Graduate Student Engineers."*— The results of the test given to the different groups can be summarized briefly. Because the test was revised after giving it to the first class in the School of Insurance Salesmanship, the scores can not be compared with the scores of the other groups. The insurance salesmanship classes had also taken Bureau Test VI., and the correlations between the scores of that test and those of Part I, were, $r = +.64$ for the first class, which took the original form of the test; and $r = +.92$ for the second class, which took the revised form of the test. Of the engineers who took Bureau Test VI, 18 also took the Bureau Test 10. For these 18, the correlation between Test VI and Part I of Test 10 was $r = +.69$; and between Test VI and Part II, the correlation was $r = +.38$. The correlation between the committee's original estimate of intelligence and Part I was $r = +.49$; and between estimated intelligence and Part II, the correlation was $r = +.76$. Evidently the estimate of intelligence was influenced by the student engineer's manifestation of engineering capacity.

Considering only the design engineers, Diagrams 12, 13, and 14 are four-fold tables showing the relation between the results of Part I and the Chief Engineer's ratings, between Part II and these ratings, and between a composite of Part I and Part II and these ratings. The composite score was made by adding the score in Part I to the score in Part II in terms of standard devia-

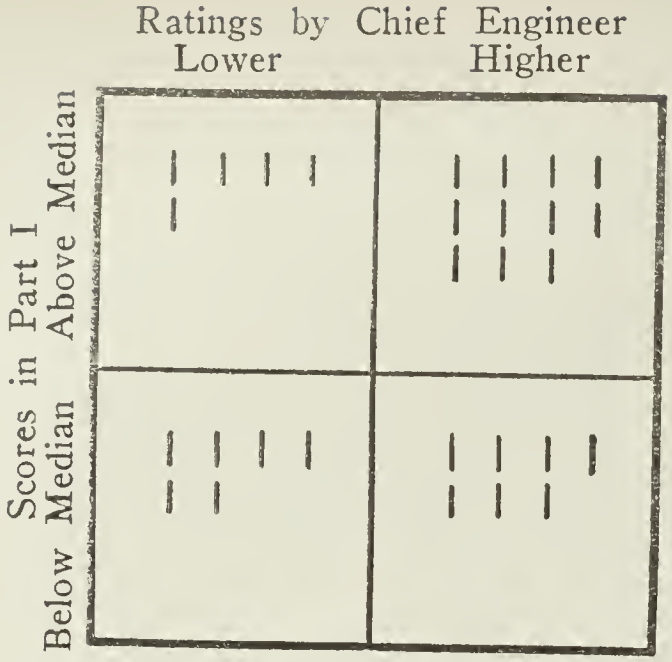

Diagram 12. Comparison of Scores in Part I with Chief Engineer's Rating of Design Engineers. $r_U = .22$.

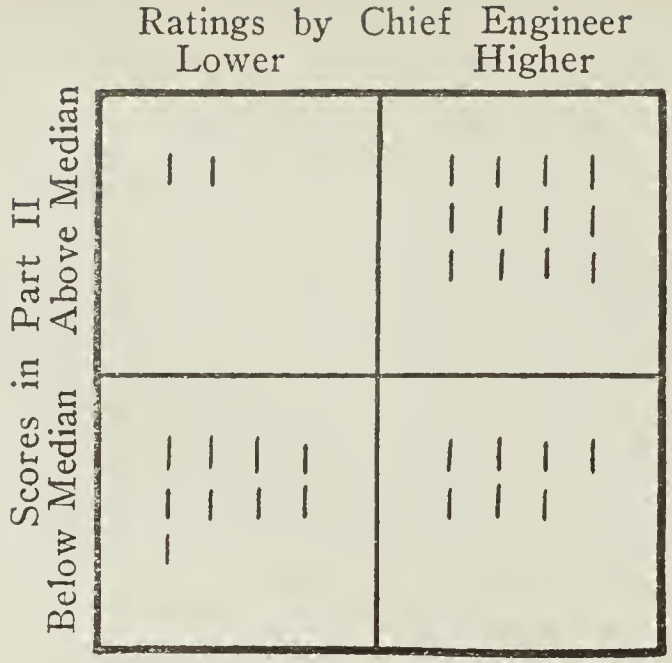

Diagram 13. Comparison of Scores in Part II with Chief Engineer's Rating of Design Engineers. $r_U = .59$.

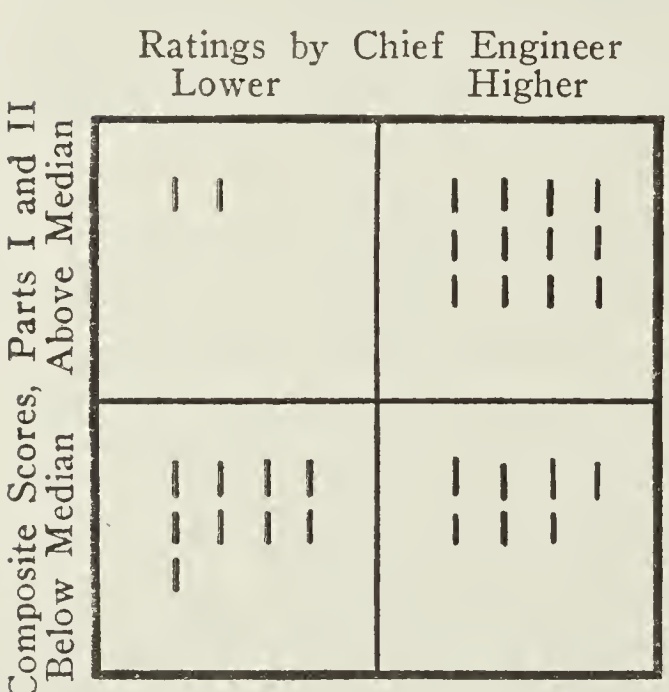

Diagram 14. Comparison of Scores in Composite of Part I and Part II with Chief Engineer's Ratings of Design Engineers. $r_U = .66$.

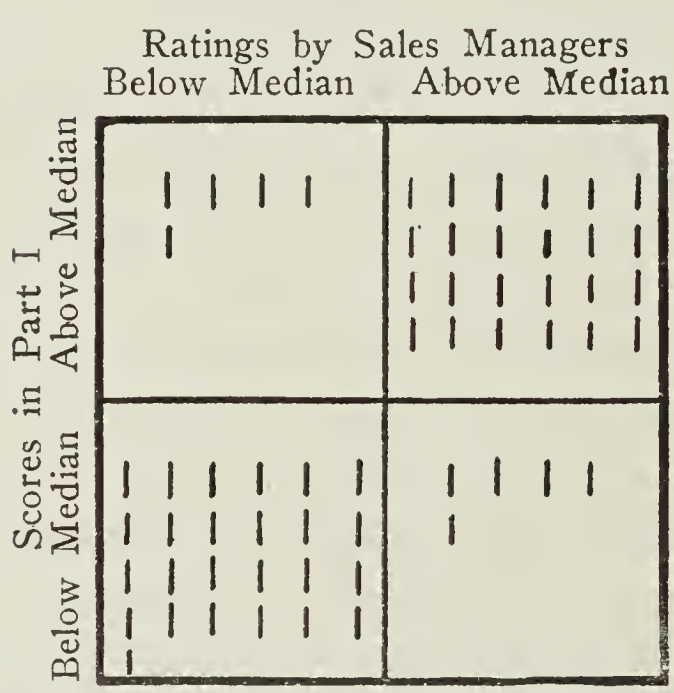

Diagram 15. Comparison of Scores in Part I with Sales Managers' Ratings of Sales Engineers. $r_U = +.86$

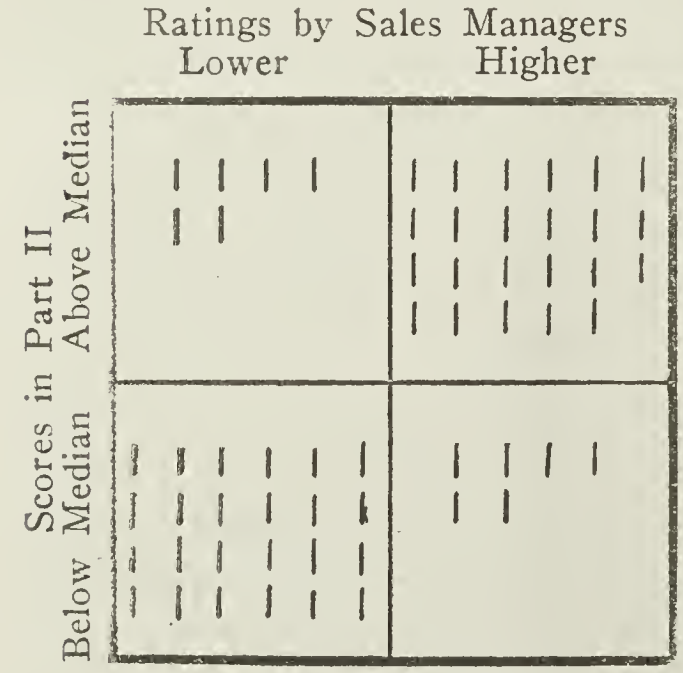

Diagram 16. Comparison of Scores in Part II with Sales Managers' Ratings of Sales Engineers. $r_U = +.81$.

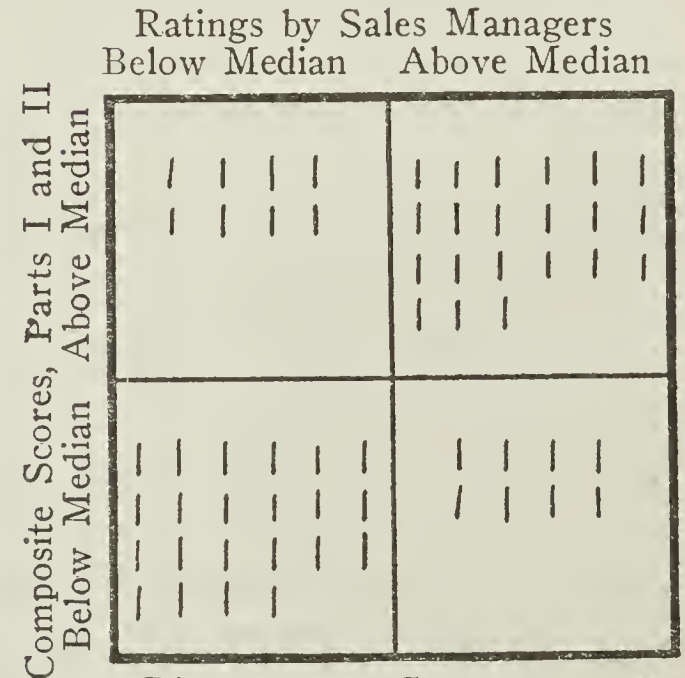

Diagram 17. Comparison of Scores in Composite of Part I and Part II with Sales Managers' Ratings of Sales Engineers. $r_U = +.66$.

tions. It is evident that Part II, the technical part prepared for design engineers, correlates more nearly perfectly with the ratings than Part I does. The composite score, which takes into account both the special engineering capacity and the general intelligence or mental alertness of the man, correlates a little more nearly perfectly. Diagrams 15, 16, and 17 show the same relations for the sales engineers; that is, the correlations between the test and the ratings made by the sales managers.

Considering again only the design engineers, the mean of the scores in Part I was 109.3; and the mean of the scores in Part II was 37.0, which is approximately *one-third* of the mean for Part I, 37.0 multiplied by three being 111.0. For the sales engineers, the mean of the scores in Part I was 87.6; and the mean of the scores in Part II was 22.7, which is approximately *one-fourth* of the mean for Part I, 22.7 multiplied by four being 90.8. Thus the sales engineers do relatively better in Part I as compared to Part II than the design engineers do. Comparing in another way, the design engineers do relatively better in Part II as compared to Part I than the sales engineers do; for the mean of their scores in Part II is more than one-third of the mean of the scores in Part I.

Diagram 18 is a scatter diagram showing the relation between Part I. and Part II. for the scores of the design engineers and the sales engineers. Diagram 19 shows the same relation between the percentiles of each man in Part I and Part II. The circles (O) represent the sales engineers; and the crosses (X) represent the design engineers. One purpose of the test is to distinguish sales engineers from design engineers. According to the hypothesis for the test, the men who did well in both parts of the test and appear in the upper right-hand quadrant of the diagram, are mentally capable of being either sales engineers or design engineers because of their superior general all-around intelligence, or because of their superior intelligence in at least these two fields. The men who did poorly in Part II. but very good in Part I, should be those whose kind of intelligence fits them better for the work of a sales engineer. The larger percentage of circles in this quadrant substantiates this part of the hypothesis. Those

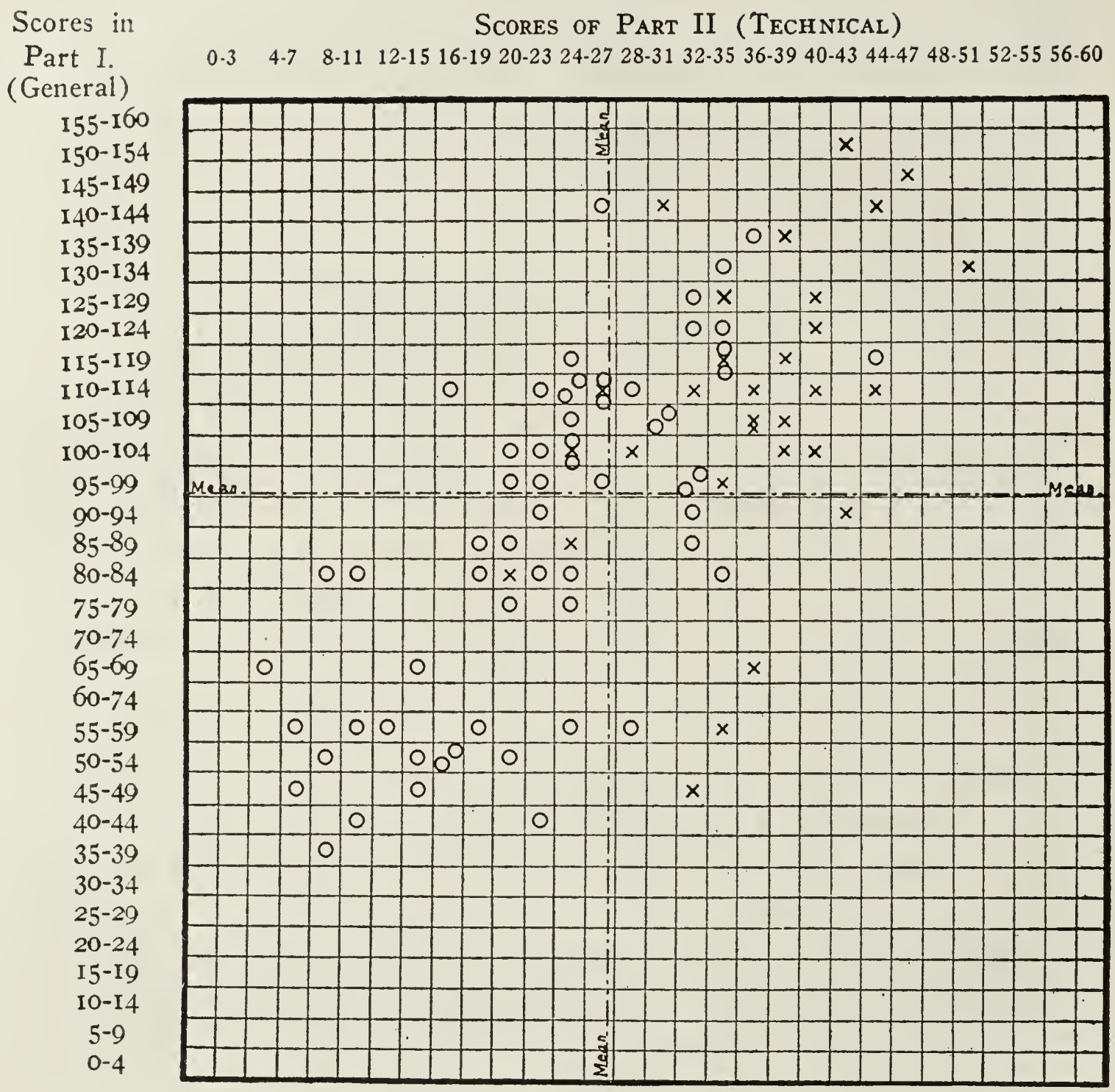

Diagram 18. Scatter Diagram Showing Relation of Scores in Part I to Scores in Part II for Design Engineers (+) and for Sales Engineers (o).

who did poorly in Part I. but very good in Part II., should be those whose kind of intelligence fits them better for the work of a design engineer. The larger percentage of crosses appearing in this quadrant substantiates this part of the hypothesis. Those doing poorly in both Part I. and Part II., might be equally successful in either line of work, as far as mental ability is concerned; but they are not as successful as any of the others might be if properly placed in the right line of work. As a whole the hypothesis is substantiated by the results. There are some

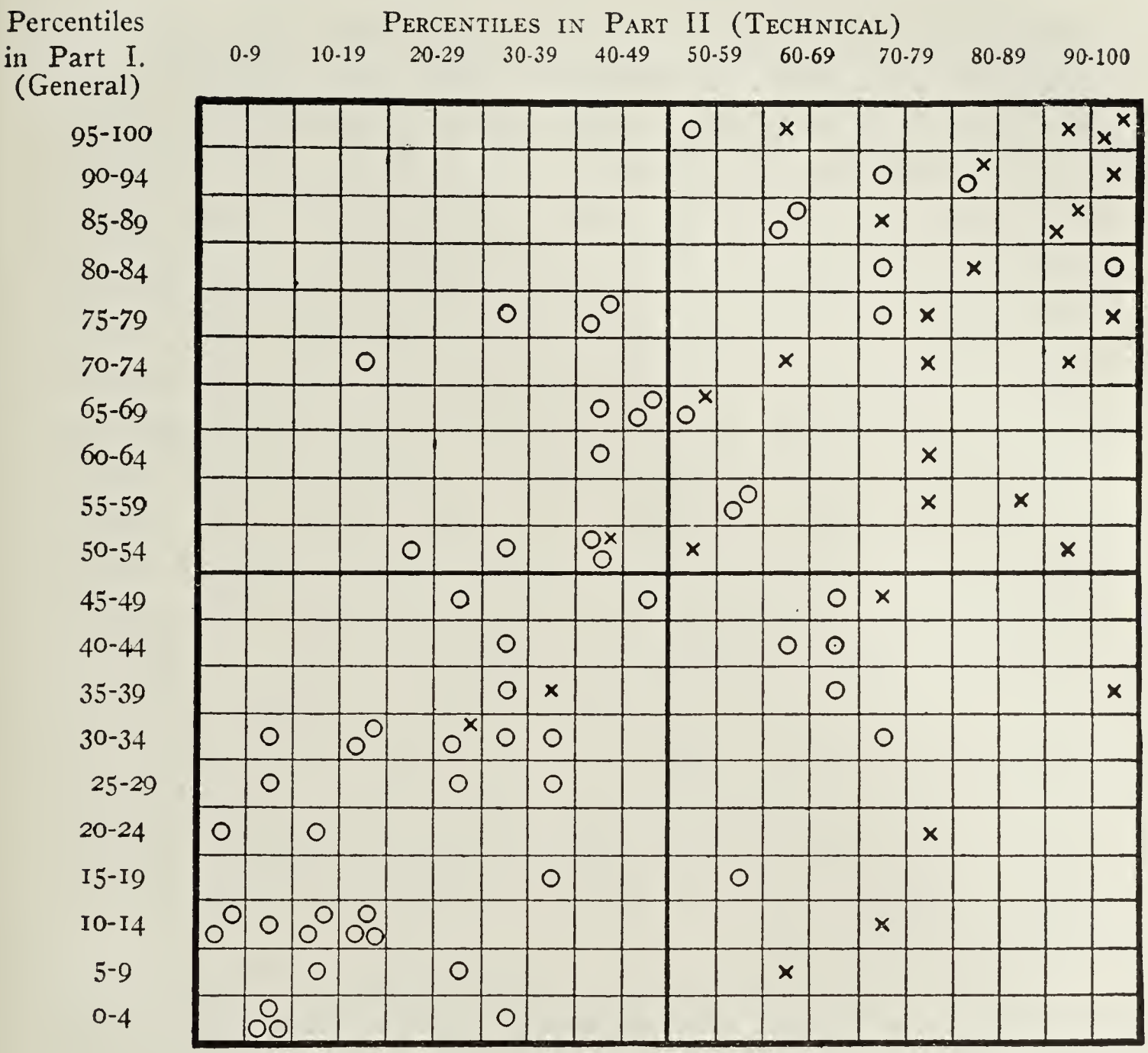

Diagram 19. Scatter Diagram Showing Relation of Scores in Part I to Scores in Part II in Terms of Percentiles for Design Engineers (+) and for Sales Engineers (o).

exceptions as seen from the positions of the circles and crosses on the scatter diagram; but investigation shows reasonable causes for these, which do not disprove the hypothesis. The test was made for graduate student engineers in the Educational Department of the Westinghouse Company, and all these engineers are always just graduated from the technical schools. Therefore, they would not have the difficulty of having specialized in industry for several years and having forgotten some of their theoretical or technical training. Some of the design engineers who took this test had been doing very highly specialized work for five years, and had forgotten some of the information in other

lines of electrical engineering. For this reason, they may not have done so well in Part II, although they were regarded by the Chief Engineer as among his best engineers, particularly because of their experience, conscientious work, and constant application. However, I do not think that the specialization or experience of the design engineers nor of the sales engineers materially affected their scores; for Part II is a test of engineering aptitude and not of engineering information, and Part I is a general intelligence or mental alertness test. The correlation between Part I and Part II was $r = +.42$ for the design engineers, and $r = +.84$ for the sales engineers. If the design engineers have special capacity for engineering, as we believe they have, it is to be expected that their score in Part II, which tests engineering capacity, would correlate less with their scores in Part I, which is a general intelligence test, than the sales engineers' scores in Part II would correlate with their scores in Part I. The scatter diagram of the scores of the design engineers in Part II shows that the correlation between the parts is lower because some of the design engineers had special aptitude in engineering, but could not do well in the general intelligence or mental alertness test.

(f) *Statistical Interpretation of the Results for Occupational Placement.*—The test is to be used in two different ways for two different purposes. The first use is to separate the men who are best fitted to be sales engineers from those who are best fitted to be design engineers. What is desired in this case is to know for what the men are best fitted by their special abilities, not considering their general intelligence or mental alertness. A man might be more successful as a design engineer and might make a better score in Part II than another man; but even so he would not be so well placed if he is placed as a design engineer when he could be still more successful as a sales engineer. Each man should be placed not where he would be merely successful, but where he could function most efficiently and be most successful. Therefore a single score in a sales test or in an engineering test could not be relied upon to place the men; for the good all-around man would do best in both kinds of work, and best in both kinds

of tests. However, some measure of the kinds of abilities or the qualitative differences in intelligence could be obtained by subtracting the score of each man in one test from his score in the other test. Suppose, for each individual, we subtracted the score of Part II in terms of the standard deviation from the score of Part I in terms of the standard deviation. The man who had a score in Part I which was considerably higher than his score in Part II would have a large algebraically positive difference between his scores, and he would be a sales engineer type of man. This great difference between his scores in each part of the test might be because he did well in Part I, or did poorly in Part II, or for both reasons. In any case, he would be better fitted for sales engineering than he would be adapted for design engineering. The man who had a score in Part I considerably lower than his score in Part II, would have a large algebraically negative difference between his scores; and he would be a design engineer type of man. This great difference between his scores in each part of the test might be because he did poorly in Part I, or did well in Part II, or for both causes. By use of this method, that is, transmuting the scores into terms of sigmas and subtracting the score in Part II from the score in Part I, those who get the greater algebraically positive differences are to be considered the more specially fitted for sales engineering; and those who get the greater negative differences are to be considered the more specially fitted for design engineering. The practical use of this method is to rank the men according to the algebraical differences between their respective scores in Part I and Part II, and then count down the list until the desired number of sales engineers is obtained. That is, the man who did well in Part I, but poorly in part II, would rank high in the list according to the algebraic difference between his score in Part I and his score in Part II, and he would be chosen for sales engineering. This method, theoretically, selects the men who can function most efficiently as sales engineers, and leaves those who can function most efficiently as design engineers.

To check this method of classifying and ranking the thirty design engineers and the fifty-nine sales engineers, the score of

each individual for Part II was subtracted from his score in Part I, both scores being in terms of their respective standard deviations. This gave positive although not the most desirable results in separating the sales engineers from the design engineers. These results are shown graphically in Diagram 20. Consider-

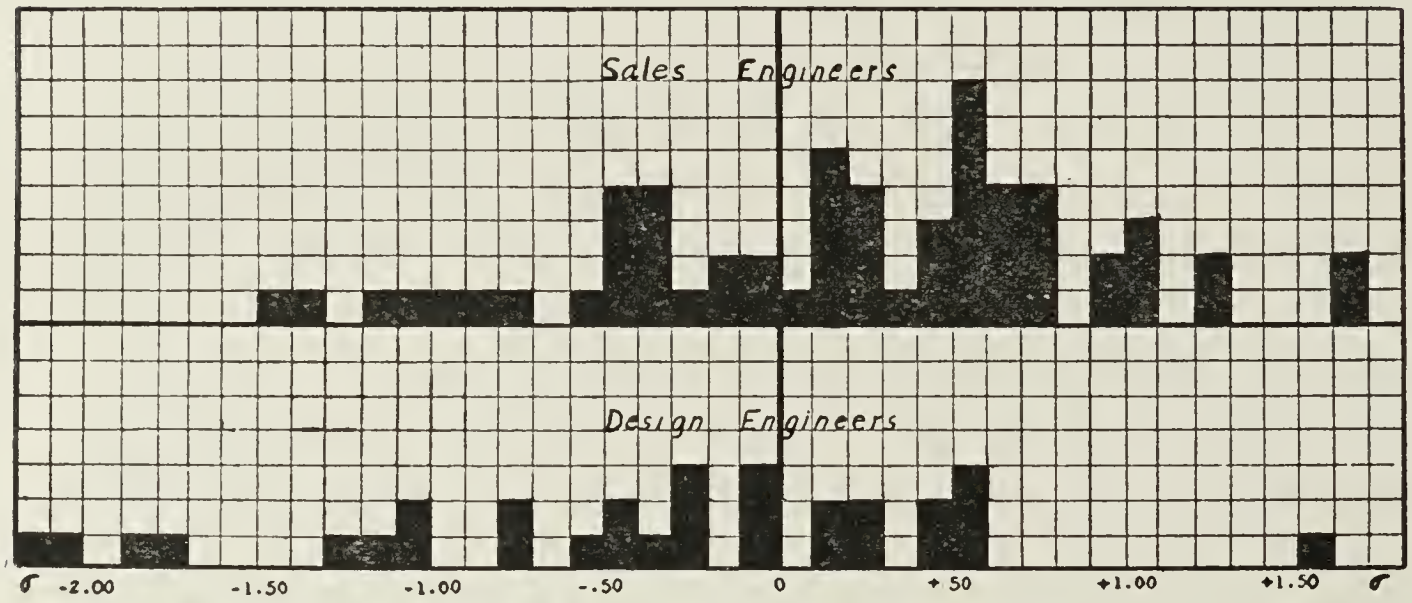

Diagram 20. Differentiation Obtained by Subtracting Scores in Part I from Scores in Part I in Terms of Standard Deviations.
Considering the diagram as a four-fold table, the engineers indicated by the test as sales engineers are 79 per cent correctly so classified; and the engineers indicated by the test as design engineers are 49 per cent correctly so classified. $r_U = + .45$.

ing the diagram as a four-fold table, this method of interpreting the results differentiates the men so that of those classed as sales engineers, 79 per cent are correctly so classed; and out of those classed as design engineers, 49 per cent are correctly so classed. The correlation between the test results treated in this way and the actual classification was $r_U = + .45$. Also, the correlation between the classification of the men by the test treated in this way and the classification of the men by the "Section II. Choice of Other Occupations" of the *Record of Interests,* was $r = +.50$. A similar and simpler method of treating the results is to transmute the raw scores into percentile ranks, and subtract the percentile rank in Part II from the percentile rank in Part I. This was done, and the classification of the engineers was practically the same; for the correlation between differences in percentile ranks (Part I minus Part II and the differences in scores in terms

of sigma (Part I minus Part II in terms of sigmas) was $r = +.97$.

The best method of dealing with the results is to divide the score in Part I by the score in Part II for each individual. This is the method which is the simplest, and it is the one which gives the most efficient use of the test as a means of differentiating the men. This method magnifies the differences among the individuals, which differences are shown by showing that the ability of each individual to deal with Part I differs from his ability to deal with Part II. That is, the ratio or quotient of a man's score in Part I divided by his score in Part II changes geometrically, instead of algebraically, as this man's special ability is greater or less. This probably makes the results agree more nearly with the practical considerations; for the extreme cases of special ability should be markedly differentiated. The genius is valued probably far greater than an actual measurement of capacity would indicate. The results of dealing with the scores by this method are presented graphically in Diagram 21. Consid-

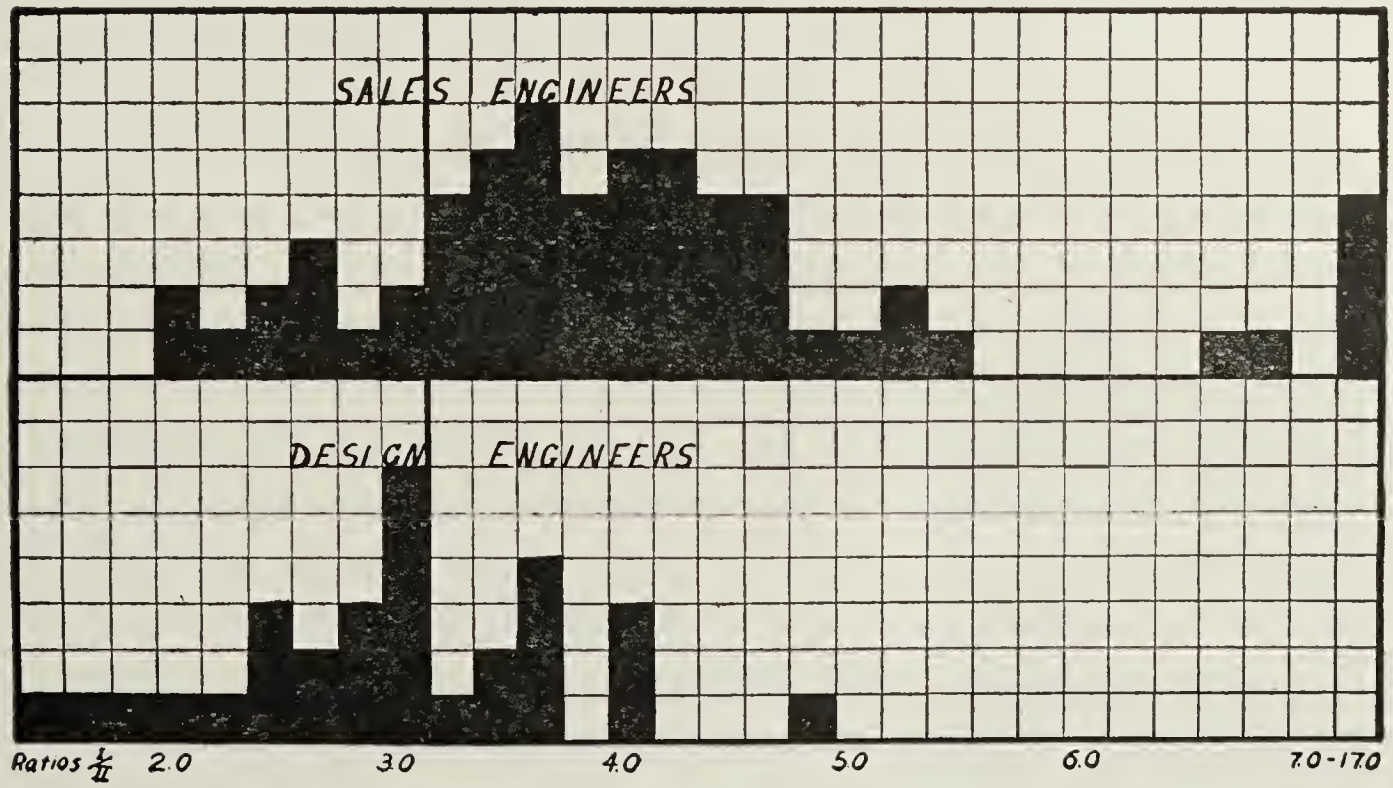

Diagram 21. Differentiation Obtained by Dividing Scores in Part I by Scores in Part II.

Considering the diagram as a four-fold table, the engineers indicated by the test as sales engineers are 81 per cent correctly so classified; and the engineers indicated by the test as design engineers are 63 per cent correctly so classified. $r_U = +.70$.

ering the diagram as a four-fold table, we have the engineers differentiated as follows:

Knowing first the actual classification of the engineers, we can say that 63 per cent of the design engineers were shown by the test to be better fitted for design engineering than 81 per cent of the sales engineers were shown to be. 81 per cent of the sales engineers were shown by the test to be better fitted for sales engineering than 63 per cent of the design engineers were shown to be. Not knowing first the classification of a group of engineers, this test can be used to differentiate them as follows: Assuming that if an engineer's score in Part I of the test is more than 3.2 times his score in Part II, he is a sales engineer, and that if his score in Part I is less than 3.2 times his score in Part II, he is a design engineer or a pure type of engineer, this test divides the engineers so that 81 per cent of those above this critical ratio (Part I at least as much as 3.2 times Part II) are sales engineers; and 63 per cent of those below it are design engineers or of a purely engineering type. (This critical ratio may be changed slightly by the change from the mimeographed form of the test to the printed form.) The correlation between the test results treated in this way and the actual classification of the men were $r_U = +.70$. Also, the correlation between the classification of the men by the test results treated in this way and the classification of the men by the *Record of Interests,* Section II, was $r = +.46$. The correlation between the marks for the engineers when the scores were treated in this way (score in Part I divided by score in Part II) and the marks for the engineers when the score in part II was subtracted from the score in Part I in terms of sigmas, was $r = +.50$. Such was the correlation coefficient obtained when the quotients (Part I divided by Part II) were correlated with differences between scores (Part I minus Part II in terms of sigmas) by the Pearson product-moment formula. However, this does not show the true relationship; for the relationship is a non-linear one; and by using the formula for *eta,* it is shown to be $\eta = .88$.

$$\eta = \frac{\Sigma}{\sigma_y} = \frac{\sqrt{\frac{S(n_x(\tilde{y}_x - \tilde{y})^2)}{N}}}{\sigma_y}$$

The second use of the test is to rank the sales engineers and the design engineers after they have been separated, so as to show who are the best design engineers, and who are the best sales engineers, considering general intelligence or all-around mental ability as well as special ability. In other words, this use of the test makes it a general intelligence or mental alertness test. The relationships of the results of the test with the estimates of the success of the engineers have already been given in the previous section. There the composite of Part I and Part II was obtained by simply adding the scores of the two parts in terms of their standard deviations. The composite does not necessarily show a higher correlation with the estimates of success than each part separately shows; for if the two parts test two widely different abilities, then combination may not give a higher correlation with the criterion. The simplest method of combining the scores is to add the percentile rank of each man in Part I to his percentile rank in Part II, and then rank the men according to these sums of percentile ranks. This gives results which are practically as reliable as those obtained by the method of combining scores in terms of sigmas.

On the basis of the results obtained so far, the test, both Part I and Part II, is being given to the graduate engineers who are entering the employ of the particular industrial firm. Only by following up these men in the lines of work which they enter later, will we finally know the value of the rating scales, of the *Record of Interests,* and of this special aptitude test.

The results already obtained on one hundred seven engineers employed by the firm during the first year that the test has been used are very similar to the results obtained on the group studied in this research. These hundred and seven men have been with the company approximately one year and they have been classified according to previous methods into sales engineers and design engineers by the executives supervising their work. The

test results were not a factor in the classification. However, assuming that the executives classified the men correctly at the end of a year, we can say that the test results alone would have classified seventy per cent of the men correctly on the day that they were employed. Beginning with June, 1921, the company will use the test and other methods recommended here as definite aids in classifying and placing the graduate engineers whom they employ.

PART III. SUMMARY OF RESULTS AND CONCLUSIONS AND RECOMMENDATIONS

X. Summary of Results

The practical problem upon which we began work was to formulate methods and means based upon sound psychological principles for differentiating graduate engineers. The results of studying various existing methods and certain proposed or newly devised ones showed that some were of value and that others were not. The results might be summarized briefly as follows:

1. Technical school grades when coming from various schools of different standards, do not differentiate the men in a large group according to their ability in industry, nor according to the kind of work which they can do best. This is with the one exception that men who are selected to be design engineers are the kind of men who made higher grades in technical schools. This was true in all subjects except in general academic subjects, particularly economics, in which the design engineers fell below their own average, and the grades of the sales engineers were above their own average, so that the grades of the two groups were practically the same in these subjects.

2. Neither the grades given in the classes of the Educational Department nor the grades given in the shop on the courses of the Educational Department show any consistency or reliability. The correlation between the two sets of grades is only $r = +.19$, and the correlation is zero with all other measures such as technical school grades, ratings, and test scores. The unreliability of

these grades and ratings is doubtless due to the method of making the ratings, of recording them, and of combining them, rather than being altogether due to the inability of the foremen to make the ratings.

3. The ratings made by the foremen on the ten different traits or qualifications show no agreement with any other measures such as shop and class grades, ratings, technical school grades, or test scores. There is high intercorrelation among the traits. This is due to two causes: (a) Some of the traits are very similar, or at least they are not well enough defined for the foremen to distinguish them; and as the foremen are not trained to make such ratings, they decide that a man is either a good man or a bad man, and then rate the man accordingly either good or bad in all traits. (b) The method of making the ratings, in terms of A, B, or C, does not give the foremen any scale or basis of measure or comparison.

4. The only traits rated by the foremen which differentiate the different groups of graduate student engineers, are tact, initiative, enthusiasm, and personality. The trait called personality is the most vague and undefined, but it shows the greatest differentiation of the men; for it is a trait concerning which the foremen really get an impression and form an opinion in regard to each man.

5. The *Interviewer's Rating Scale* as already in use by the Company, has given results that have significant correlation with test scores, with later estimate of intelligence, and with technical school grades. The trait called Personal Qualities, as previously defined, had a high correlation with other traits, and was too broad, inclusive, and ambiguous to give reliable results. It was then more narrowly defined so as not to be ambiguous and not overlap or include the other traits to be rated.

6. The *College Instructor's Rating Scale* was prepared to enable the college instructors, professors, or deans to record a definite estimate of a senior on specific traits. This is expected to give more reliable and significant ratings of a man than a verbal expression of opinion of the man in general.

7. The *Shop and Class Rating Scale* was prepared to take

the place of the method of rating on ten traits by A, B, and C. It requires ratings on a few very significant traits or qualities; but it is expected to enable the foremen and the instructor to have a common understanding of just what is meant by these traits and to give a reliable and significant rating that will differentiate the engineers according to essential qualifications.

8. The use of the *Record of Interests* shows that men in different lines of work have different interests. That is, the insurance Salesmen as a group, have always had interests different from either sales engineers or design engineers. The sales engineers are men who have been more interested in economic, public, and social affairs. The design engineers are men who have been more interested in science, machinery, and actual construction or fabrication of things.

9. The engineers and the salesmen showed a definite tendency to like or be interested in occupations which in nature of work were similar to those they were already following. The kind of occupations which they thought would give them the greatest satisfaction to follow, was a significant criterion of the kind of work in which they could be and were already successful.

By computing for each engineer the percentage which his choices of occupations of a sales nature were of his total number of choices, a definite measure of his sales engineering interest as opposed to design engineering interest was obtained. By this measure, 78 per cent of the sales engineers were of a sales type; and 82 per cent of the design engineers were of an engineering type. Or assuming that we did not know the actual occupations of the engineers, those engineers which this test of interests alone would select for sales engineering, would be 89 per cent correctly placed or classified; and the men which the test of interests selected for design engineering would be 68 per cent correctly placed or classified.

10. Personnel Bureau Test VI, a general intelligence test similar to the Army Alpha intelligence test, gave results that did not differentiate the engineers according to the kinds of work for which they were thought to be fitted. The only men who had scores significantly different from the other engineers, were the

design engineers. They were a highly selected group of men who had shown ability in the engineering classes of the Company's Educational Department.

11. The general intelligence test gave scores that correlated, r = +.48, with intelligence as estimated by two executives of the Educational Department who were intimately associated with the graduate student engineers one year.

12. The general intelligence scores correlated, r = +.38, with technical school grades, and with interview ratings at the time of employment, r= +.58; but the correlations were zero with shop and class ratings, which did not correlate with any other criteria, and were evidently unreliable.

13. *Test 10, A Test for Graduate Student Engineers,* gave positive although not perfect results in separating the sales engineers from the design engineers. Knowing first the actual classification of the engineers, we can say that 63 per cent of the design engineers were shown by the test to be better fitted for design engineering than 81 per cent of the sales engineers were shown to be. 81 per cent of the sales engineers were shown by the test to be better fitted for sales engineering than 63 per cent of the design engineers were shown to be. Not knowing first the classification of a group of engineers, this test can be used to differentiate then as follows: Assuming that if an engineer's score in Part I of the test is more than 3.2 times his score in Part II, he is a sales engineer, and that if his score in Part I is less than 3.2 times his score in Part II, he is a design engineer or of a pure engineering type, this test divides the engineers so that 81 per cent of those above this critical ratio (Part I 3.2 times Part II) are sales engineers, and 63 per cent of those below it are design engineers or of a purely engineering type. (This critical score may be changed slightly by a change from the mimeographed form of the test to the printed form.)

14. The differentiation of the engineers resulting from the use of Test 10 showed a comparatively high correlation with the results of the *Record of Interests.* The correlation was r = +.50 when the scores in Part II were subtracted from those in Part I in terms of sigmas. The correlation was r = +.46

when the differentiation was obtained by dividing the scores in Part I by the scores in Part II. This shows not only that there is high correlation between interest and special ability, but also that the Record of Interests and Test 10 give reliable results.

15. Test 10 used as a general intelligence or mental alertness test for sales engineers gave scores that correlated, $r = +.86$ and $+.81$ with estimated success. The same test used as a general intelligence test for design engineers gave scores that correlated, $r = +.22$ and $+.59$, with estimated success.

XI. Conclusions and General Principles Derived from the Study

1. The study of the technical school grades show that such grades cannot be made of practical use to differentiate engineers for various kinds of work, except in a very general way. Sales engineers do comparatively better in economics than in engineering subjects. The design engineers make much lower grades in economics than they do in mathematics and science, engineering, and shop.

2. When foremen are asked to rate men under them on a large number of traits which are not carefully defined, the ratings are unreliable and of little use as a measure of the value of the men rated; and such ratings are particularly of no use for classifying the men and placing them in positions for which they are best fitted. Generalizing, we can say that ratings made by different people on traits which are understood by some to be one thing and by others to be another, are of no value. This difficulty arises if the traits are not carefully defined in terms that the raters can understand; and there is the same difficulty if there are many traits to be rated, some of which overlap or include others so that they can not be differentiated. The ratings are unreliable if there is no scale or standard with which the men can be compared. This basis of comparison may be the other men of the same group; but there must be definite comparison instead of arbitrary grades or marks. Finally, the ratings or marks must be recorded in such a form that they can be readily tabulated and actually used in placing the men.

4. Carefully prepared acquaintance-comparison rating scales, such as the *Interviewer's Rating Scale* and the *Shop and Class Rating Scale,* give much more reliable results than forms on which arbitrary grades or marks are recorded opposite certain names of traits. The acquaintance-comparison rating scale enables the rater to compare the one to be rated with other people as concrete examples of different grades of the same trait.

5. The use of the *Record of Interests* shows that men in different lines of work have different interests. The interests of a person are not in just one specific occupation, but they are general to the extent that they pertain to very similar or closely allied occupations or activities. Interest in a certain class of activities is a criterion that the person will be interested in any other very similar activity. By similar activity is meant one that requires much the same information, training, experience, kind of materials and tools worked with, mental activity, personality, ideals of accuracy and perfection, and social attitude.

6. In the engineering profession, men cannot be differentiated for different lines of work by tests which measure what is commonly known as general intelligence or mental alertness. Men in the same kind of engineering work differ in this intelligence as greatly as men in *different* kinds of engineering work. The differences which fit these men for different kinds of work, are something other than differences in intelligence.

7. General intelligence as measured by a general intelligence test does show a significant positive correlation with the success of engineers in the same kind of work.

8. One man differs from another in having special abilities, which functioning in an integrated form as a kind of intelligence, can be measured and used as criteria for placing the man in the kind of work for which he is best fitted.

9. The occupational interests of a man show a definite correlation with the kind of intelligence or special abilities which he has, and with the kind of occupation in which he is successful.

XII. Specific Methods and Practices Recommended

1. Before senior engineers who are being graduated from the technical schools, are employed, they should be rated by the use of rating scales. The representatives of the Company who interview the seniors, should use the *Interviewer's Rating Scale.* Before the interviewers start on their visits to the colleges, they should carefully make a *Master Rating Scale* from the list of engineers whom they know intimately and who have passed through the Educational Department within the previous five years. If possible, two or three interviewers representing the Company should interview the senior and make ratings independently, and then combine the ratings later.

2. After the interviewers have returned to the home office and have prepared a large tentative list of seniors who are to be considered for employment, the name of each senior should be put on a blank *College Instructor's Rating Scale,* and this blank sent to the dean, professor, or instructor who can be depended upon to give a reliable rating of the man under consideration. A rating by more than one instructor is desirable if it can be obtained without imposing on the instructors. Most of the professors are glad to help place their students. If the representative believes that the senior will be desired by the Company and that this senior will make application, he should get the rating from the professor while visiting the college or as soon as possible.

3. As soon as the graduate student engineers enter the Educational Department of the Company, they should be under observation in the shop and in the class to be rated at the end of each month by means of the *Shop and Class Rating Scale.*

4. Within the first two months after the graduate student engineer enters the Educational Department of the Company, he should be given the *Test 10, A Test for Graduate Student Engineers.* This should be scored, first to determine for what kind of work the engineer is probably best fitted; second, to determine what the rank in general intelligence is.

5. At the end of two months or just before it is necessary to segregate the graduate student engineers for intensive training in

some particular line of work, the student engineers should be requested to fill out the blank entitled *Rceord of Interests.*

6. At the end of two months or when it is necessary to know into what line of work the student engineers are going, the results of the rating scales, the test, and the *Record of Interests,* should be combined. The impressions and opinions concerning the engineers which the executives, interviewers, and instructors of the Educational Department have recorded on the rating scales, should have a weight or vote of one-third in the final composite measure of the men; the test should have a vote or weight of one-third; and the *Record of Interests* should have a weight or vote of one-third to determine for what line of work the engineer should be recommended. In case of doubt, any two of these measures or criteria should determine for what work the particular man should be recommended. Of course the judgments of the executives concerned will be the final criteria, but their impressions and opinions should be based upon dependable data and be corrected by this data.

7. The student engineer should be interviewed with his *Record of Interests* before him and the interviewer; and in the interview the student should be advised to enter the line of work for which he is best fitted as determined by this *Record of Interests,* the test, and the rating scales. This advice should be given as an intelligent recommendation; but the student should not be urged against his will to enter a particular line of work. If the student objects to the recommendation, it should be discussed in the light of the results of the *Record of Interests* and of *the test.*

8. After the student engineers have been segregated and assigned tentatively to their respective lines of work, a copy of the Record of Interests and the results of the test should be transmitted to the heads of the respective departments in which the men will work.

9. The results of all rating scales, tests, and *Record of Interests,* should be carefully recorded and filed; and the later success or record of the engineers should be systematically followed

up in order to check the reliability and value of the methods and means of selection, classification, and placement being used.

10. Some person qualified for personnel research work should be assigned the responsibility for keeping rating scales and tests in proper use, working up the results, carrying on the research and follow-up work, and planning and directing new lines of research which should be undertaken to increase the efficiency of the educational, placement, and other personnel work.

11. The rating scales, tests, and *Record of Interests* should be studied to make further improvements as a result of their use. A duplicate or alternate form of the test should be prepared, which could be given in case there is reason to believe there has been coaching for the first form.

12. In the light of results obtained in the study of this problem with graduate student engineers, research work in personnel problems should be extended to the apprentices, the clerical workers and the shop employees of the Company.

BIBLIOGRAPHY

Benge, E. J. Standard Personnel Practice. H. W. Wilson Co., New York. 1920.

Bingham, W. V. Army Personnel Work. *Journal of Applied Psychology,* March, 1919, vol. 2, pp. 1-12.

Frankel, L. K., and Fleischer, A. The Human Factor in Industry. Macmillan Co. 1920.

Committee on Classification of Personnel. The Personnel System of the United States Army. Vol. I, History of the Personnel System. Vol. II, The Personnel Manual. Superintendent of Public Documents, Washington, D. C. 1920.

Hollingworth, H. L. Vocational Psychology. D. Appleton & Co. 1916.

Kitson, H. D. Interest as a Criterion in Vocational Guidance. *Educational Review,* vol. 24, pp. 207-214, March, 1916.

Link, Henry C. Employment Psychology. Macmillan Co. New York. 1919.

Mann, Charles R. A Study of Engineering Education. Bulletin No. 11, Carnegie Foundation, 576 Fifth Avenue, New York. 1918.

Moore, Bruce V. General Intelligence Determined by Its Weakest Essential Element. *Journal of Applied Psychology,* vol. 4, pp. 151-161. June-Sept., 1920.

Scott, W. D. Changes in Some of Our Conceptions and Practices in Personnel. *Psychological Review,* 1920, No. 27, pp. 81-94.

Scott, W. D. A Fourth Method of Checking Results in Vocational Selection. *Journal of Applied Psychology,* March, 1917, vol. 1, pp. 61-66.

Tead, O., and Metcalfe, H. C. Personnel Administration. McGraw-Hill. New York. 1920.

Thorndike, E. L. The Permanence of Interests and Their Relation to Abilities. *Popular Science Monthly,* vol. 81, pp. 449-456. December, 1912.

Thurstone, L. L. Mental Tests for Engineering Students. *Proceedings of the Society for the Promotion of Engineering Education,* vol. 27, 1919, pp. 113-119.

Yoakum, C. S., and Yerkes, R. M. Army Mental Tests. Henry Holt Co., New York. 1920.